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STATIC AND FATIGUE TEST PROPERTIES FOR WOVEN AND NONWOVEN S-GLASS FIBERS

By

Martin B. Cutler
Robert L. Pinckney

April 1969

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

CONTRACT DA 44-177-AMC-440(T)
VERTOL DIVISION
THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA

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DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA 23604

This program was carried out under Contract DA 44-177-AMC-440(T) with Boeing Vertol Division.

The data contained in this report are the result of research conducted to investigate the static and dynamic mechanical properties of S-glass fiber-reinforced epoxy resin systems over a temperature range of -65°F to 160°F. These studies included effects of simulated environmental exposures to humidity, temperature, artificial sun, and rain.

The report has been reviewed by the U.S. Army Aviation Materiel Laboratories and is considered to be technically sound. It is published for the exchange of information and the stimulation of future research.

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STATIC AND FATIGUE TEST PROPERTIES FOR WOVEN AND NONWOVEN S-GLASS FIBERS

FINAL REPORT

D8-0926

By

Martin B. Cutler
and
Robert L. Pinckney

Prepared by

Vertol Division
The Boeing Company
Philadelphia, Pennsylvania

for

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

SUMMARY

The objective of this program was to investigate the static and dynamic mechanical properties of epoxy resin bonded S-glass fibers over a temperature range of -65°F to 160°F. Included in the program were the effects of material degradation from simulated environmental exposures to humidity, temperature, artificial sun, and rain at periods of 300 hours and 30 days. Other conditioning effects were comprised of flexural sandwich beams that were exposed to actual climatic conditions encountered in the Mid-Atlantic region of the United States for a period of 15 months.

Additional investigations included the effects of fabrication processing which employed a standard cure cycle and an additional postcure cycle on laminates, sandwich panels, and structural adhesives. Evaluations were made to determine the effects of the cure parameters on the fatigue life and static strength of the materials.

The test program was formulated to obtain mechanical properties from specimens fabricated from woven and unwoven prepreg materials. The properties derived from each specimen configuration were as follows:

- Tensile and compressive mechanical properties of laminates
- Flexural and edgewise compression data on sandwich beams with aluminum honeycomb core
- Fatigue characteristics of laminates and sandwich beams
- Static and fatigue properties of torsional tubes
- Static and fatigue properties of double lap adhesive joints

The tests and the results are tabulated in appropriate engineering formats as illustrated in the report appendix. S-N curves are included depicting the tensile and flexural fatigue characteristics of laminates and weathered and unweathered sandwich beams for various conditioning exposures.

FOREWORD

Acknowledgement is made to the following personnel for their assistance in preparing this report:

Stress Analysis	Steve Beshore Thomas Patterson
Specimen Fabrication and Static Testing	Fen Zelley Edward Frantz Pat Fannon John Malloy
Fatigue Testing	Dale Austin

The program summarized in this report was performed under Task IF162204A17003.

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LIST OF SYMBOLS

σ	unit stress, lb/in.^{2}
A	cross-sectional area, in.^{2}
Lg	effective gage length, in.
$\frac{\Delta P}{\Delta y}$	change in load per change in deflection, lb/in.
E	modulus of elasticity, lb/in.^{2}
$\bar{x}$	arithmetic mean
3σ	three times standard deviation
n	total number of observed values
N	number of cycles to failure
°F	temperature, degrees Fahrenheit
ksi	unit stress, 10^3 x lb/in.^{2}
σ_f	sandwich facing stress, lb/in.^{2}
M	applied sandwich bending moment, in.-lb
b	sandwich width, in.
c	sandwich core thickness, in.
d	total sandwich thickness, in.
t	sandwich panel thickness, in.
E_B	sandwich bending modulus, lb/in.^{2}
a_n	sandwich moment arm at 1/4 beam span, in.
I	sandwich moment of inertia, in.^{4}
L_n	distance between sandwich beam reaction points, in.
σ_c	compressive sandwich stress, lb/in.^{2}

P	applied load, lb
$\mu\varepsilon$	micro-strain, in./in.
psig	autoclave gage pressure, $lb/in.^2$
t_{nom}	average sandwich face thickness, in.
G	shear modulus of elasticity, $lb/in.^2$
$\frac{\Delta T}{\Delta \phi}$	change in torque per change in angular twist, in.-lb/rad
L_T	unsupported tube length, in.
J	polar moment of inertia, $in.^4$
T	applied torque, in.-lb
D_o	outside tube diameter, in.
D_i	inside tube diameter, in.
α	tube wrap angle, degrees
ALT	alternating stress, psi
R	stress ratio

INTRODUCTION

This research was conducted under U.S. Army contract DA 44-177-AMC-440(T) and was directed by Dr. Robert Echols, Physical Sciences Division, U.S. Army Aviation Materiel Laboratories (USAAVLABS), Fort Eustis, Virginia. The purpose of this research program was to obtain necessary engineering information on the static and dynamic properties of aluminosilicate (S-glass) fiber-reinforced composite materials for use in the design of advanced helicopter airframe structures.

Major emphasis in the program was placed on the mechanical properties of the aforementioned materials which are applicable to the design of rotary-wing and V/STOL propellers. Studies and tests of composite propellers and rotors have demonstrated the improved performance characteristics surpassing those currently being used. Improved aerodynamic effectiveness and structural integrity have been noticed illustrating the feasibility of utilizing composites as a primary aircraft structural material.

In order to achieve improvements in the field of rotary-wing and V/STOL aircraft, further gains must be realized in developing rotor blade technology. Research and development must be initiated in order to improve rotor efficiency. This effort would generate the required flexibility in tooling and fabrication processing not attainable with current metal manufacturing. Utilization of fiber-reinforced structures can allow design freedom in selecting specific performance characteristics associated with propeller fabrication such as weight, stiffness, torsional response, and fatigue.

FABRICATION AND TEST RESULTS

LAMINATE FABRICATION

The prepreg materials XP251S, 1002S, and BP907-143S were initially dimensioned as shown in Figure 1. The tool surfaces were treated with a release agent (usually Garan 225) and the plies laid up per Figure 2. The 4130-steel and aluminum 2024-T3 tapered doublers were used for unidirectional and cross-ply specimens, respectively. The doubler surfaces were degreased, Vacublast cleaned, and coated with BR1009-8 primer and finally air dried. The FM-1000 adhesive was then applied between the doubler and prepreg surfaces. The caul or tooling plate (Figures 3 and 4) was then assembled over the layup, vacuum bagged, and then cured per the following schedule as shown in Figures 5 and 6.

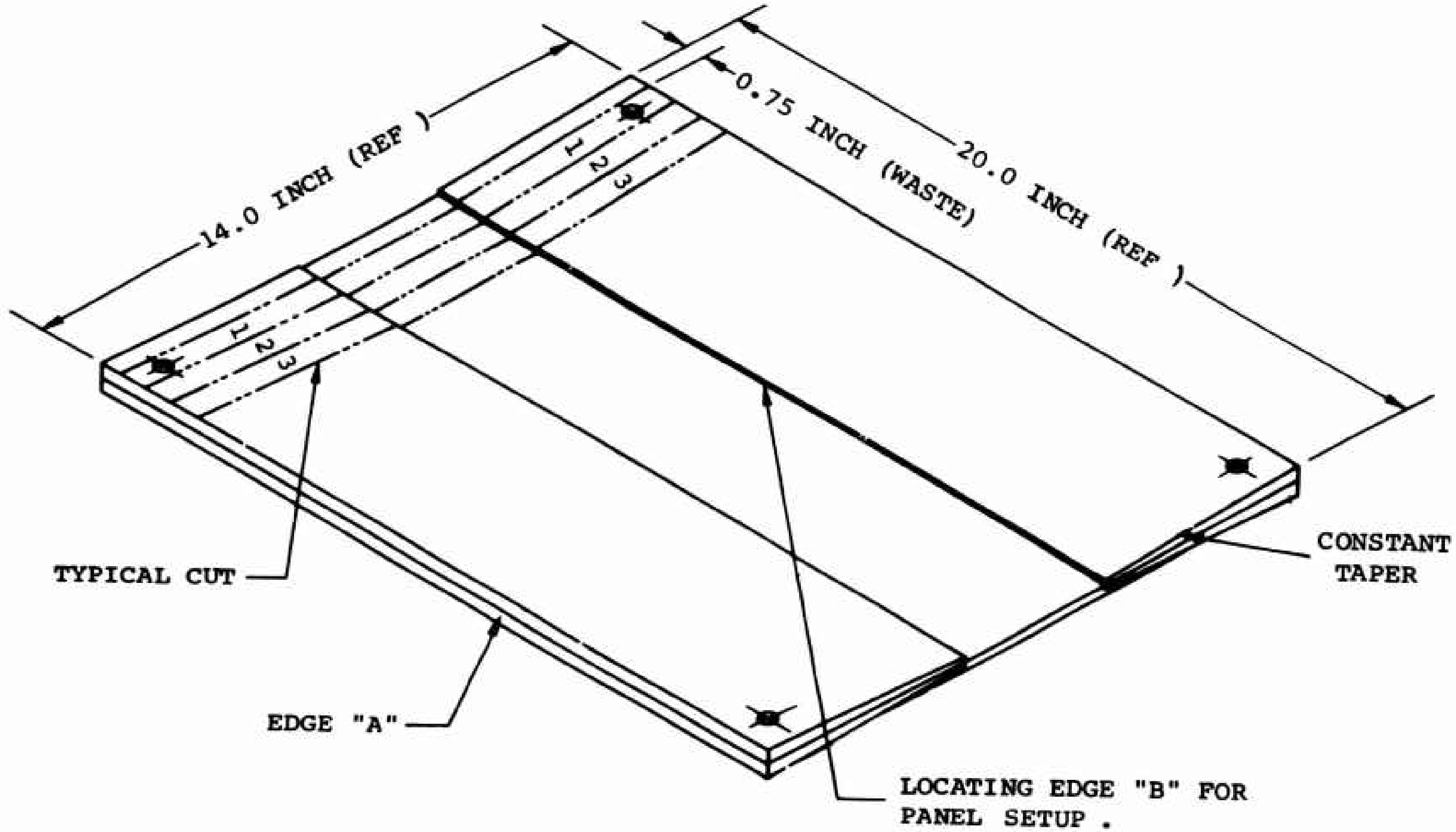
The test specimen was cut from the cured panels as shown in Figure 2. Conventional methods were used in machining the specimens, with emphasis on minimum fiber damage and loss of material. To accomplish this task, carbide cutoff wheel techniques were employed followed by a careful grinding process utilizing soft carbide wheels (see Figures 7 and 8).

LAMINATE TESTING (STATIC)

The purpose of the laminate tests was to determine the tensile and compressive strengths and associated moduli of epoxy resin laminates reinforced with S-glass fibers and 143-style fabric. Measurements of material degradation were made on compression specimens stored in a condensing humidity chamber exposed to 100 percent humidity at 120°F for 30 days. Upon removal from the chamber, the specimens were tested at ambient temperatures (75°F).

The specimens were tested in compliance with Federal Test Method Standard 406, Method 1011, on an Instron Universal Testing Machine (Model TTC) at a crosshead speed of 0.05 inch per minute. An extensometer was utilized for recording deformations at 75°F and 160°F test temperatures. Special chambers were used for testing specimens at the -65°F and 160°F temperature range. The test setup is illustrated in Figure 9.

The configurations of the tensile laminates are those of the tapered doubler tension-tension type shown in Figures 10, 11, 12, and 13. The materials were Scotchply nonwoven prepregs XP251S and 1002S and woven fabric prepreg BP907-143S.



NOTE: CUTTING WHEEL SHALL BE SET AT 90 DEGREES WITH EDGE A

Figure 1 . Fiber Glass Tensile Specimen Panel Configuration.

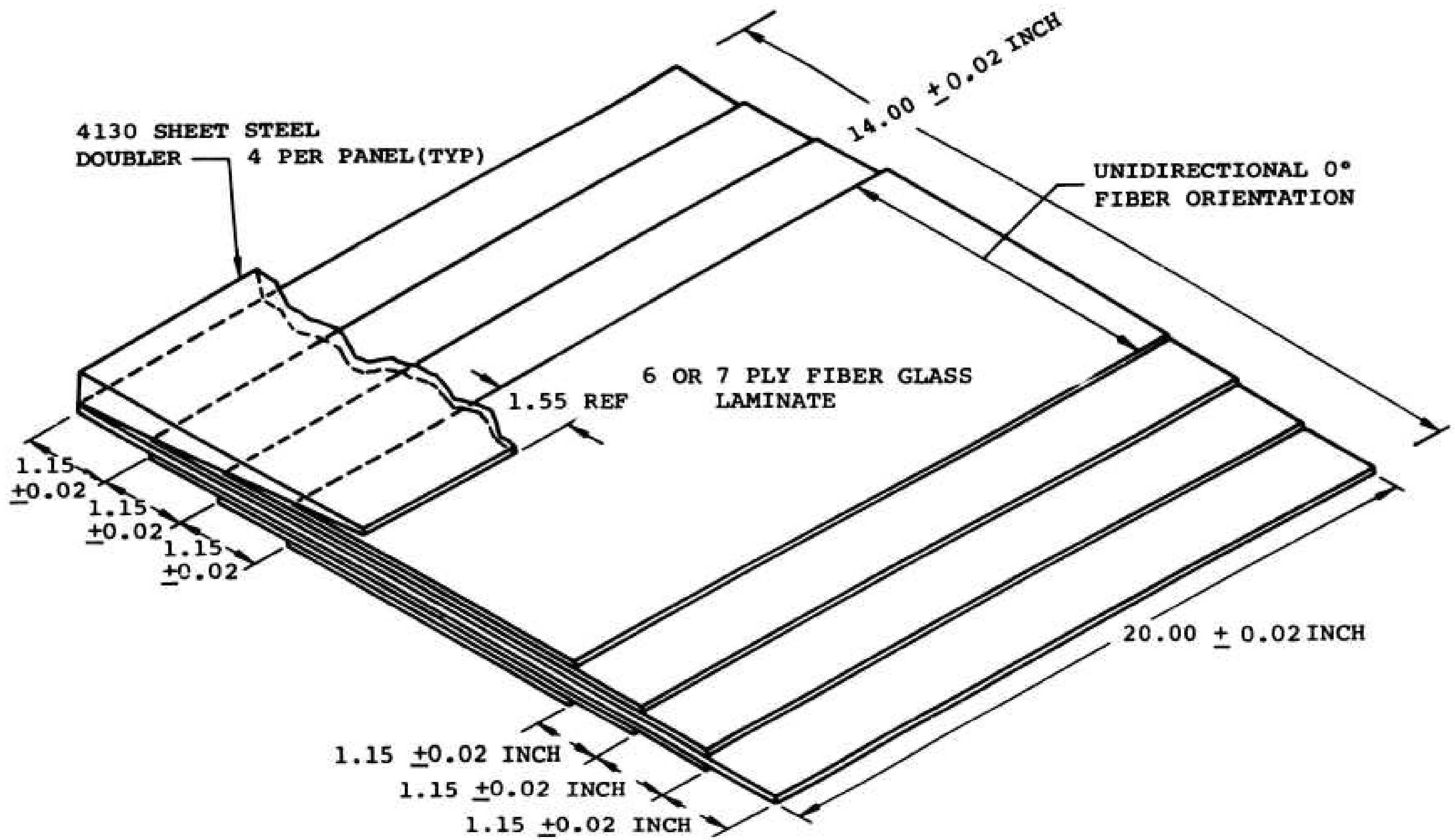


Figure 2. Unidirectional Tension Laminate Panel Detail.

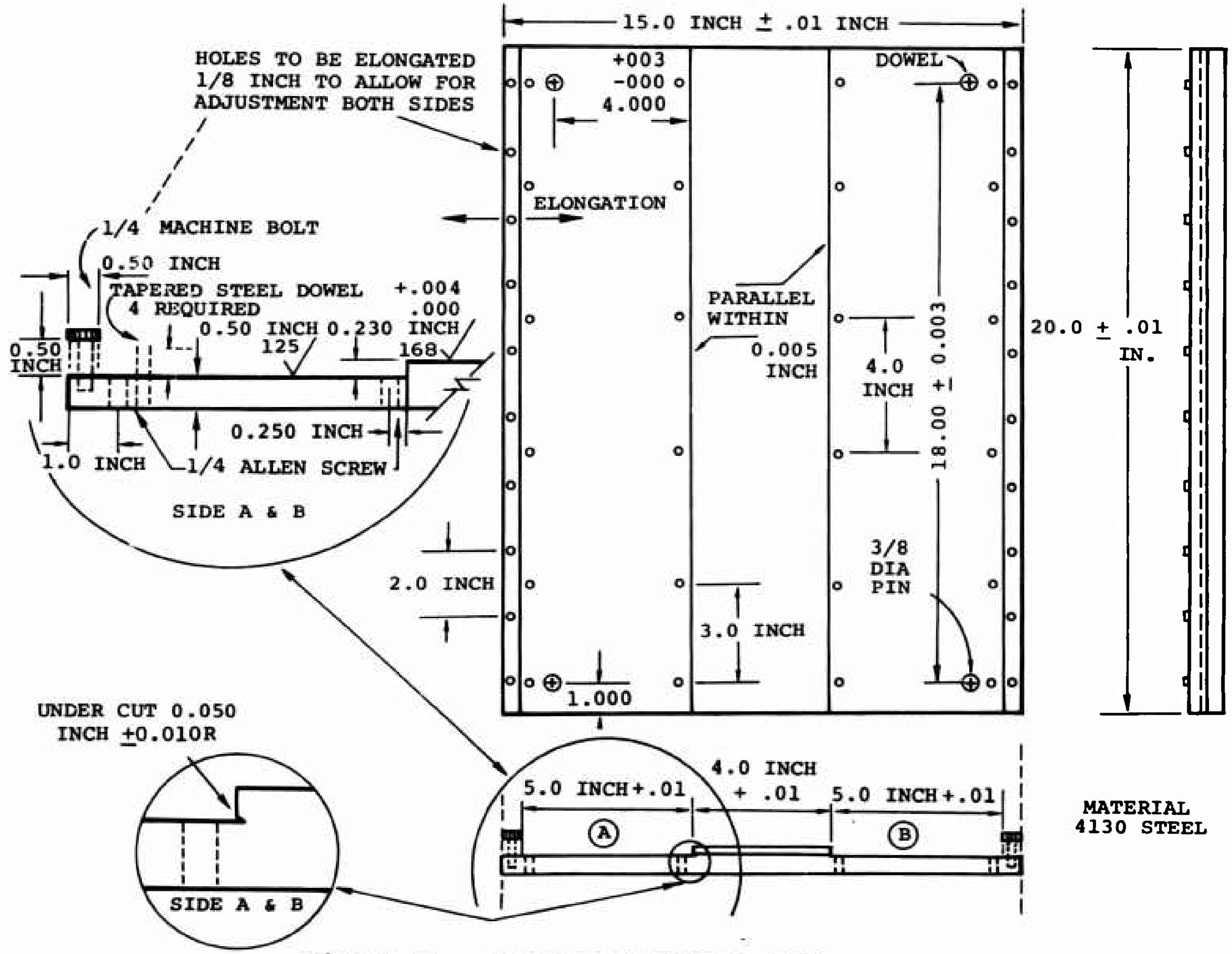


Figure 3. Tension Laminate Tool.

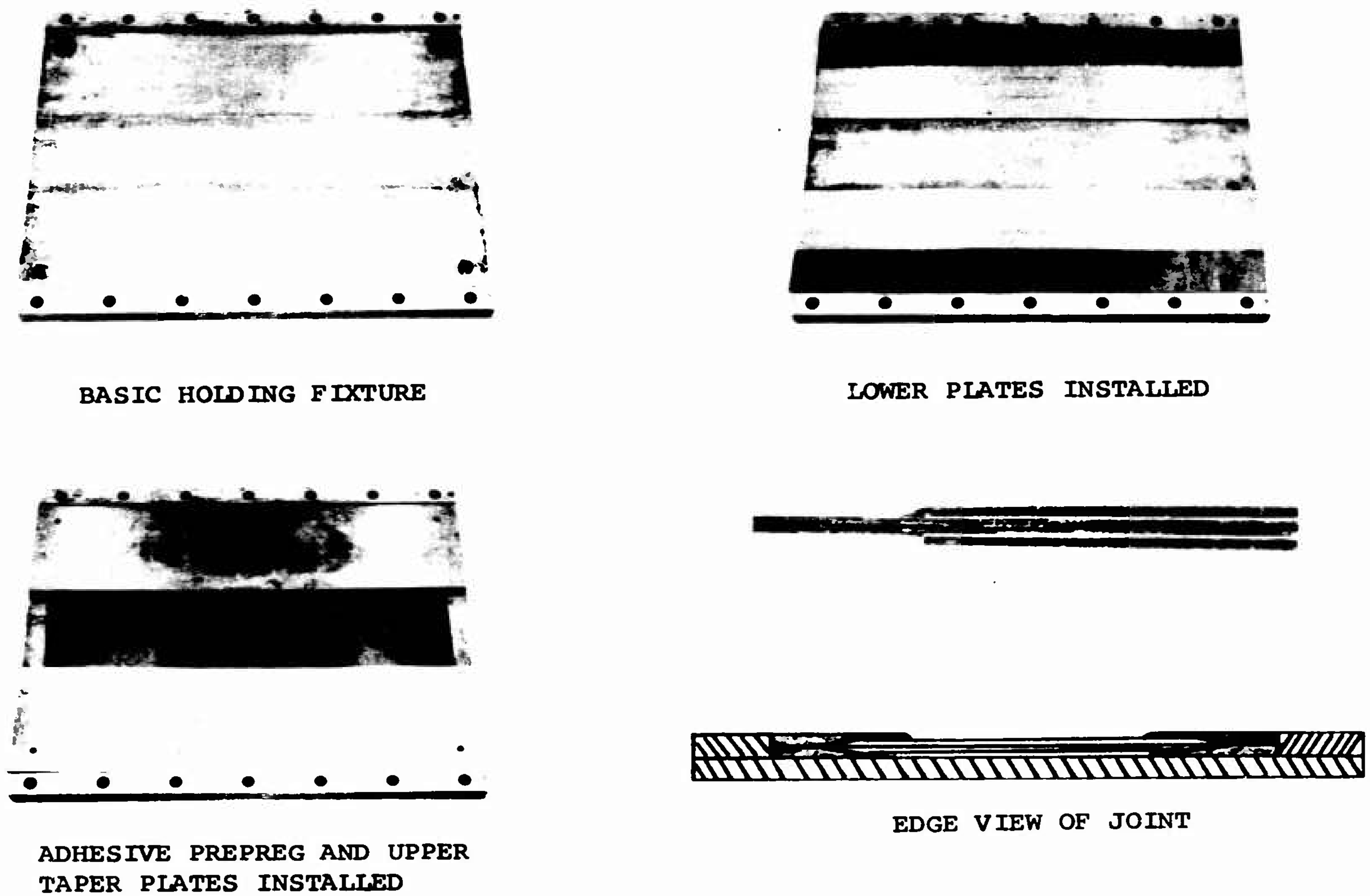


Figure 4. Taper Grip Joint Fabrication.

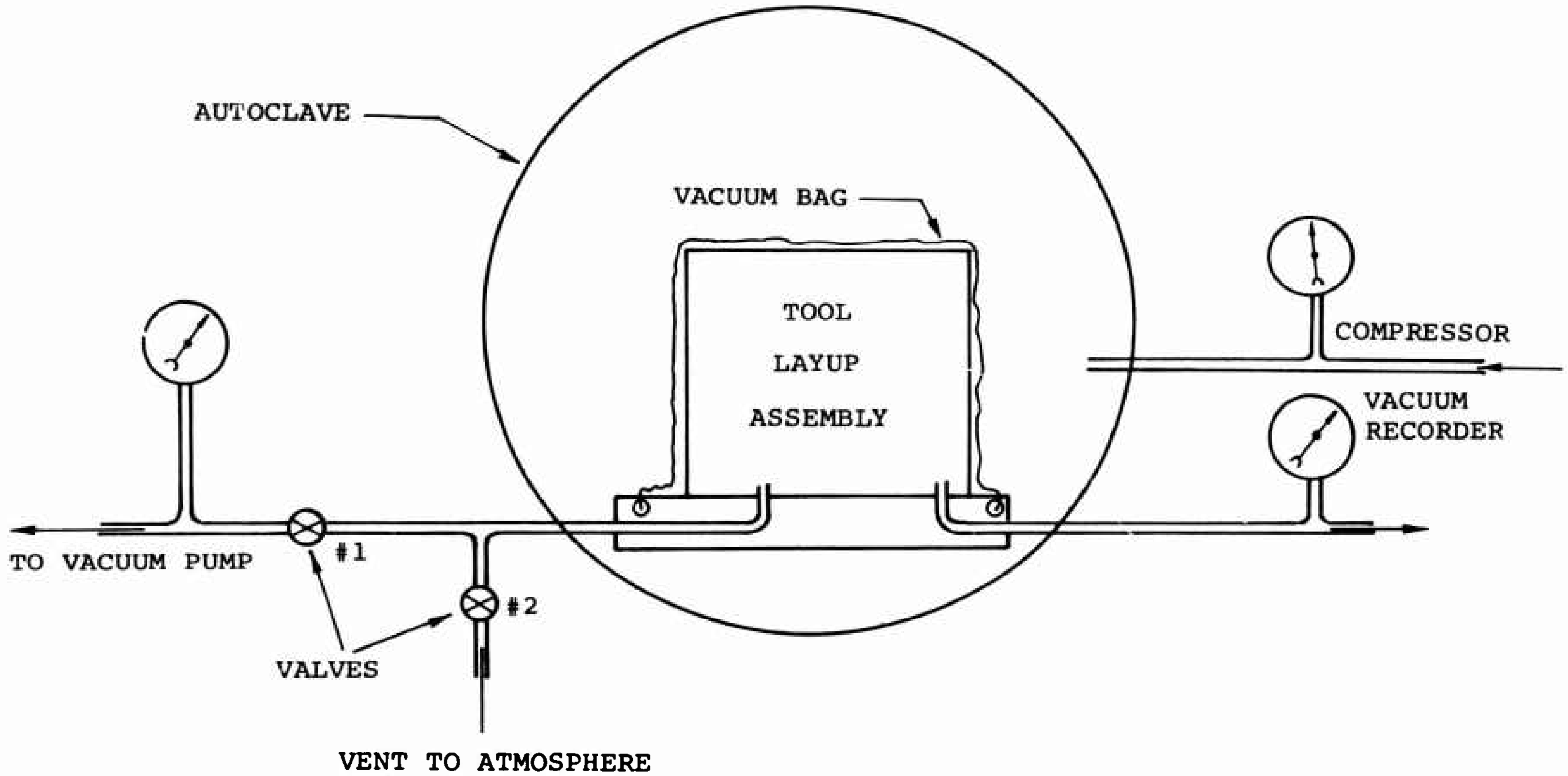


Figure 5. Required Autoclave Vacuum Configuration.

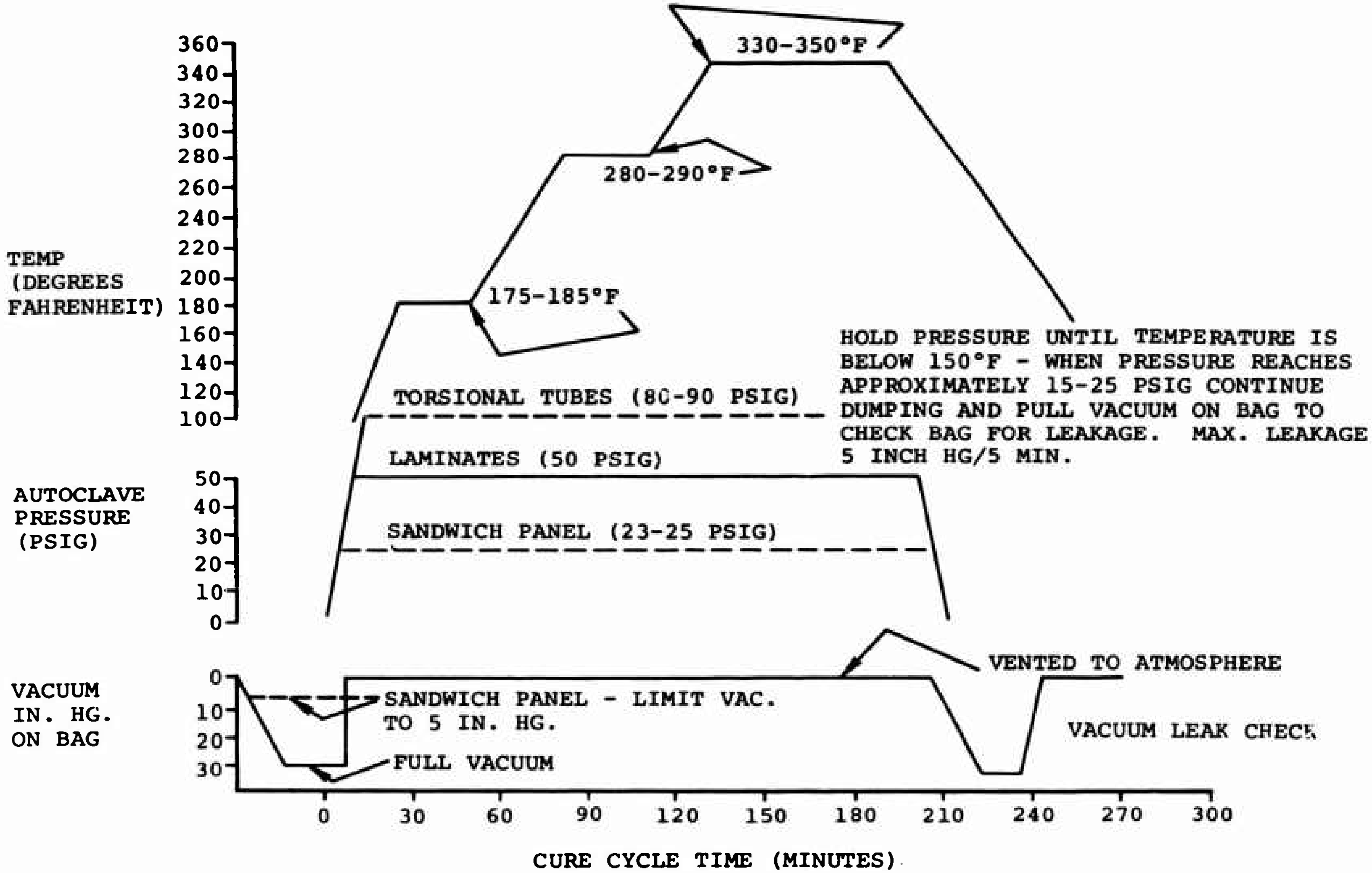
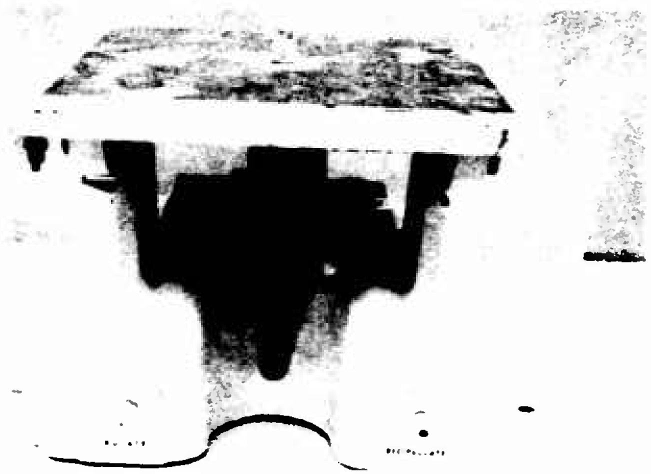


Figure 6. Autoclave Laminate Cure Cycle.

BAND SAW-ROUGH TRIM



ROUTER-CONTOUR MACHINING

EDGE GRINDER

OIL MIST LUBRICATOR

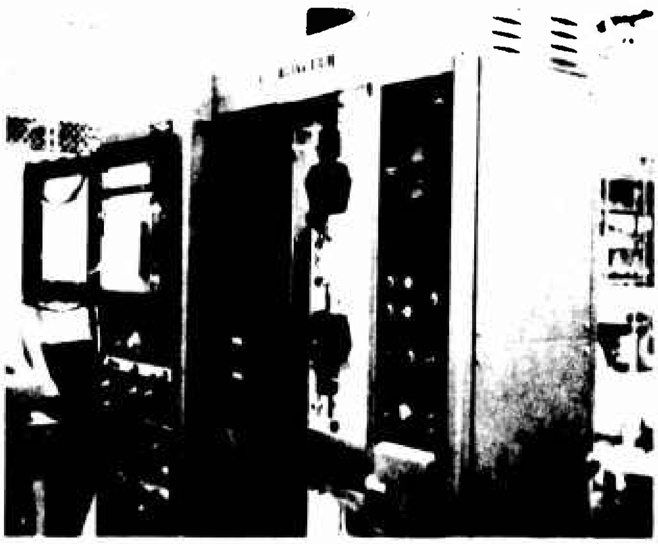
Figure 7. Specimen Machining Equipment.

EDGE GROUND 8X

CORE DRILLING SHOWING TYPICAL MACHINED SURFACES

SURFACE GRINDING MACHINE WITH CUTOFF WHEEL

Figure 8. Surface Grinding Machine and Typical Machined Suraces.



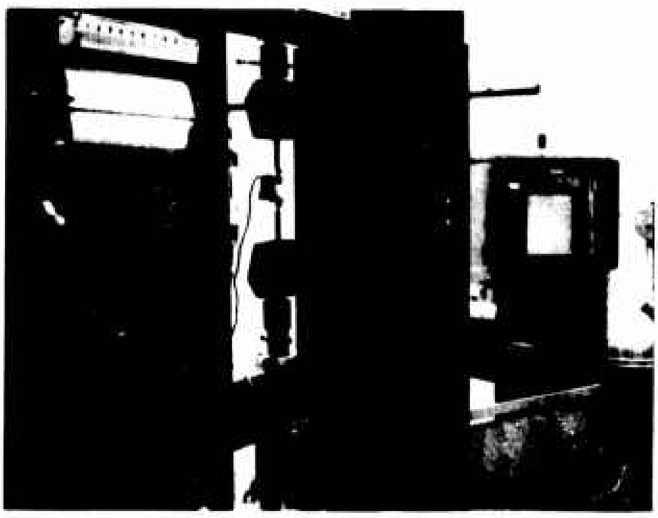
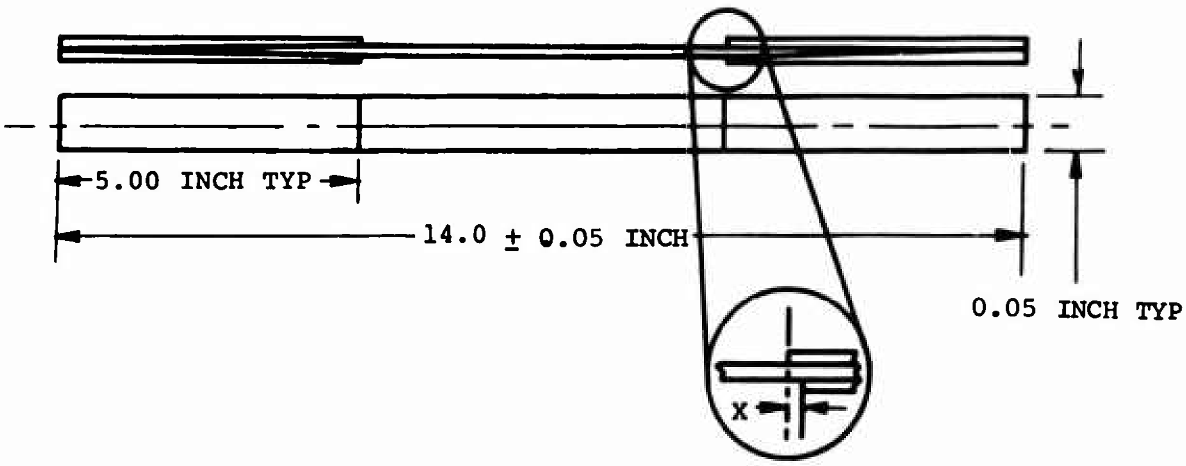


Figure 9 . Tension Laminate Equipment for Tests at Room Temperature.



NOTES: 1. THICKNESS (NOM) = 0.043 INCH

THICKNESS OF FIBER GLASS SHALL BE MEASURED AT FOUR EQUALLY SPACED POINTS ALONG THE SPECIMEN TEST SECTION. ALL MEASUREMENTS WILL BE RECORDED ON SPECIAL SPECIMEN MAPPING FORM PROVIDED. THE MAXIMUM AND MINIMUM THICKNESS SHALL NOT VARY BY MORE THAN 0.003 INCH.

2. ALL COMPOSITE EDGES SHALL BE SQUARE AND FREE OF BURRS, NICKS, GOUGES, RESIN CRACKS, FRAYED FIBERS, AND DELAMINATIONS.

3. "X" SHALL NOT BE GREATER THAN 0.020 INCH.

Figure 10. Half-Inch-Wide Unidirectional Tension Laminate Specimen.

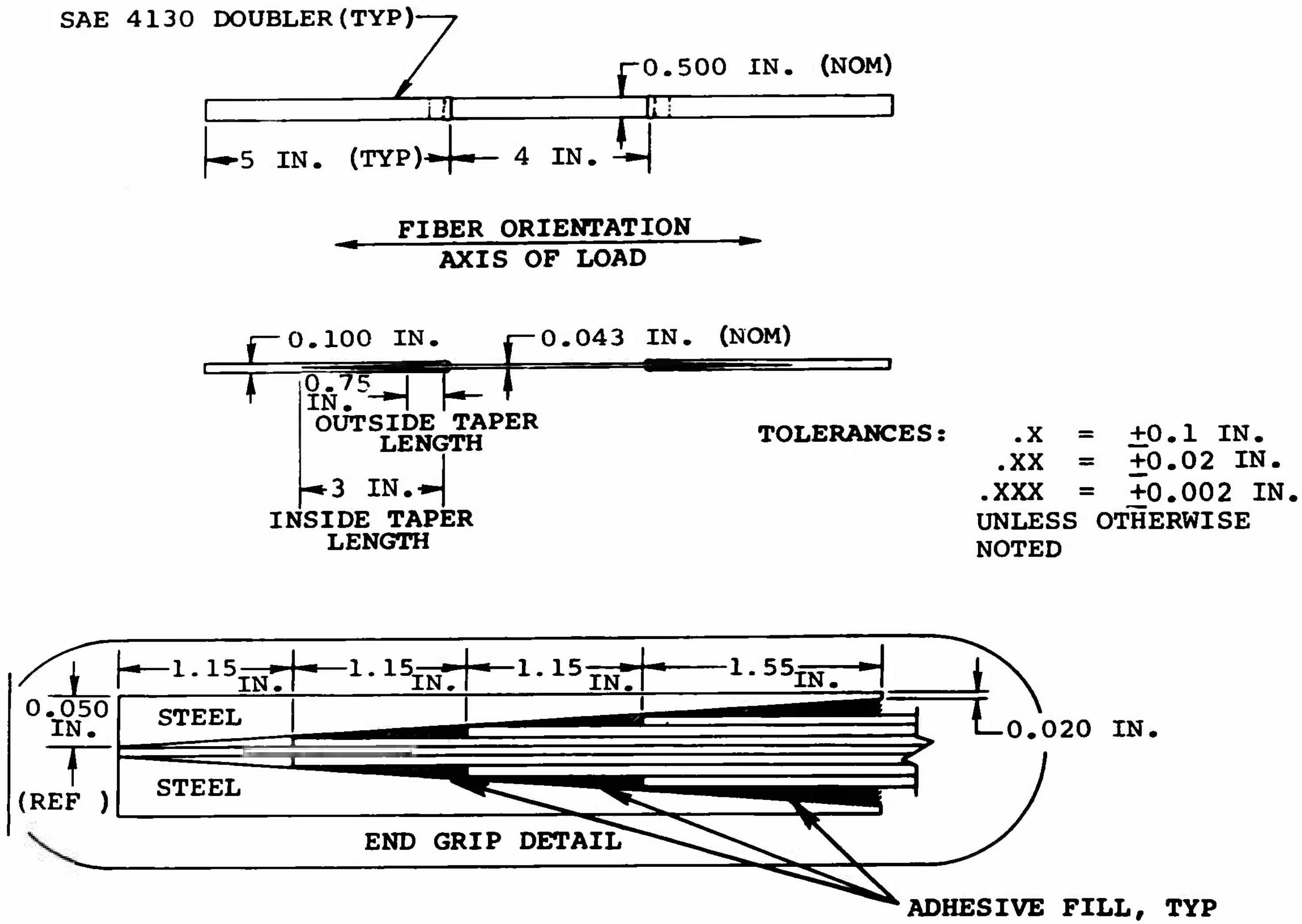


Figure 11. Fiber Glass Tensile Specimen Configuration.

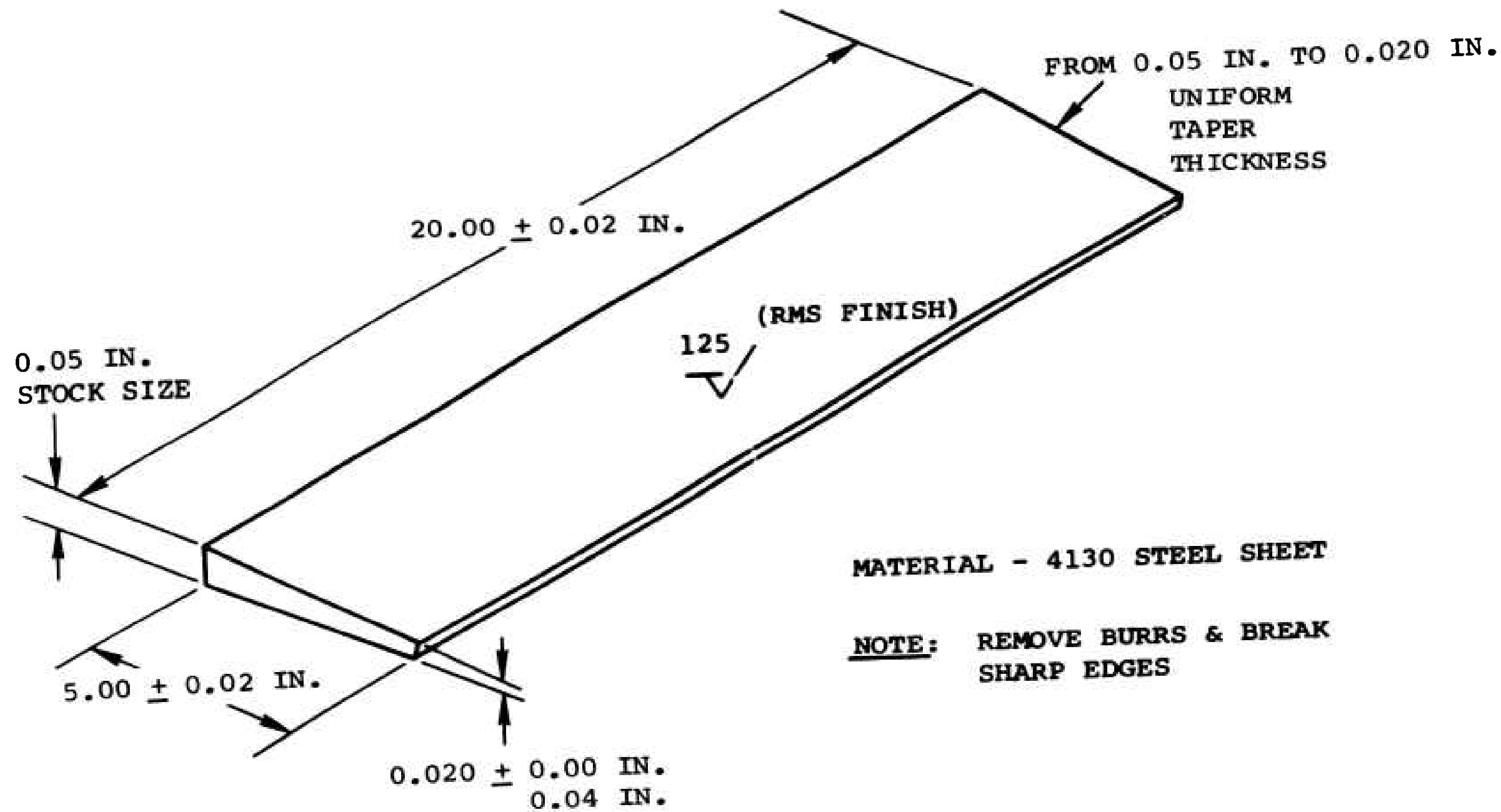
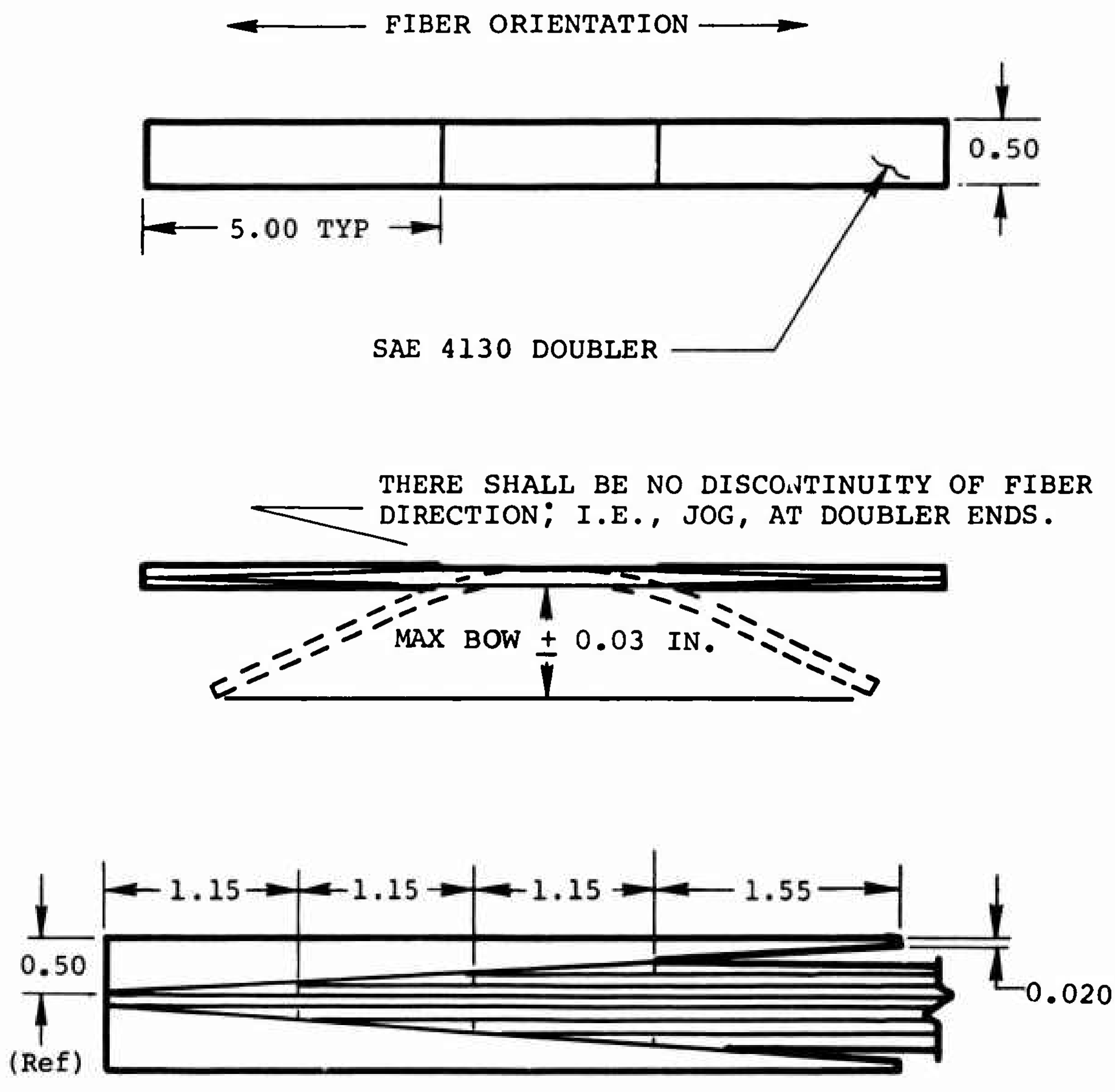


Figure 12. Tapered Steel Doubler Grip.



NOTES:

1. Doublers are single stage bonded with FM 1000 to the cure cycle per Figure 6.
2. Test section is 4.00 inches.
3. All dimensions shown are in inches.
4. Edges to be parallel to within .001 inch.
5. Tolerances: XXX = ± 0.002, .X = ± 0.03
6. All composite edges shall be square and free from burrs, nicks, gouges, resin cracks, frayed fibers and delaminations.

Figure 13. Axially Loaded Unidirectional Specimen.

The following equations were used in expressing laminate strength and modulus as recorded in Tables VII and VIII.

$$\sigma = P/A,$$

$$E = \frac{\Delta P}{\Delta Y} \frac{L_g}{A}$$

where

P = maximum load, lb

A = cross-sectional area, in.^{2}

L_g = effective gage length, in.

σ = unit stress, psi

$\frac{\Delta P}{\Delta y}$ = change in load per change in deflection, lb/in.

E = primary modulus, psi

Reference is made to Tables I and II which show the average laminate strengths and moduli. The highest strength average was recorded at 239,000 psi for unidirectional 1002S laminates tested at room temperature. The lowest strength average was approximately 24,000 psi for 1002S crossply at the same temperature. The BP907-143S specimens exhibited average strengths between 78,700 and 165,000 psi over the test temperature regime. The moduli were generally consistent and reasonably valid in comparison to other pre-established values. The range was 1.35 x 10^6 psi for 1002S crossply at 160°F to 8.43 x 10^6 psi for XP251S unidirectional at room temperature.

Table III shows the variable percentages of resin content for room temperature prepreg panels. The highest tensile strength recorded was 255 x 10^3 psi for 1002S unidirectional at 28.8 percent resin content. The lowest value was 24.03 x 10^3 psi for 1002S crossply at 31.8 percent resin content.

The reported stress and moduli for the laminates tested are recorded within the elastic limit of the material. The results, however, are questionable in this area because of frequent doubler failures for the unidirectional specimens. However, complete breaks generally occurred for the crossply laminate at all temperatures. The 143-style fabric specimens did have breaks at room temperature and 160°F, but debonded at the doublers in the -65°F range.

The delamination effect of the unidirectional specimens at all test temperatures was a problem. The failure mode occurred

TABLE I . LAMINATE TENSILE TEST DATA SUMMARY

Panel Number	Material Type	Fiber Layup (Degrees)	Test Temp (°F)	Number of Specimens	Average Tensile Strength (ksi)	Average Primary Modulus (10^6 psi)
L-1B	1002S	0	75	2	261.55	7.18
L-2	1002S	0	75	3	255.0	7.59
L-2B	1002S	0	75	4	203.2	6.69
	1002S	0	160	3	177.06	6.54
	1002S	0	-65	3	77.7	7.0
L-3	1002S	±45	75	3	24.03	2.19
L-4	1002S	±45	75	6	24.08	1.93
	1002S	±45	160	3	21.06	1.35
	1002S	±45	-65	3	31.43	3.1
L-5B	XP251S	0	75	4	247.0	7.67
	XP251S	0	160	3	231.9	7.69
	XP251S	0	-65	3	62.36	8.10
L-6B	XP251S	0	75	3	143.6	8.33
L-7	XP251S	±45	75	3	25.76	2.55
L-8	XP251S	±45	75	6	25.48	2.74
	XP251S	±45	160	3	23.96	1.64
	XP251S	±45	-65	3	27.06	3.4
L-9	BP907/ 143S	0	75	3	165.5	5.31
L-9B	BP907/ 143S	0	75	3	139.7	4.50
L-10B	BP907/ 143S	0	75	3	121.3	4.47
	BP907/ 143S	0	160	3	115.06	3.81
	BP907/ 143S	0	-65	3	78.70	5.2
L-25	XP251S	0	75	3	209.2	8.44
L-25B	XP251S	0	75	2	146.4	8.50

TABLE II. LAMINATE COMPRESSION TEST DATA SUMMARY

Material	Fiber Layup (Degrees)	Panel Number	Test Temp (°F)	Number of Specimens	Average Compressive Strength (10^3 psi)
		L-11A	75	3	89.40
	0		75	3	95.38
		L-11B	160	3	56.07
			-65	3	89.31
1002S			*	3	75.35
		L-12A	75	3	25.53
	±45		75	3	26.90
		L-12B	160	3	17.37
			-65	3	36.41
			*	3	21.61
		L-13A	75	3	96.10
	0		75	3	112.06
		L-13B	160	3	75.50
			-65	3	113.08
XP251S			*	3	106.12
		L-14A	75	3	28.98
			75	3	30.44
	±45		160	3	18.35
		L-14B	-65	3	39.00
			*	3	26.54
		L-15A	75	3	90.53
			75	3	83.74
BP907	0		160	3	58.92
		L-15B	-65	3	100.86
			*	3	66.20

* Specimens conditioned in a condensing humidity chamber (100 percent humidity) at 120°F for 30 days and tested within 30 minutes at ambient temperature.

TABLE III. LAMINATE TENSION SPECIMEN RESIN BY WEIGHT

Panel Number	Specimen	Material	Specimen Weight (Grams)	Specimen Weight Loss (Grams)	Resin Content By Weight	Average Percent
L-2	1	1002-S	3.6564	1.075	30.0	28.8
	2	1002-S	3.9034	1.4323	27.5	
L-3	1	1002-S	3.8521	1.2069	32.7	31.8
	2	1002-S	3.6540	1.1929	31.4	
	3	1002-S	3.2112	1.0108	31.4	
L-5	1	XP251S	2.8876	0.6476	22.5	23.9
	2	XP251S	3.1725	0.7192	22.7	
	3	XP251S	2.8505	0.7532	26.5	
L-7	1	XP251S	2.420	0.4728	19.5	21.2
	2	XP251S	2.5195	0.5560	22.2	
	3	XP251S	2.5011	0.5460	22.0	
L-9	1	BP907/(143S)	2.7427	0.9627	35.2	35.1
	2	BP907/(143S)	1.9790	0.6900	35.0	

most frequently at the doubler location rather than the desired specimen area. The failure may be attributed to suggested factors such as the following:

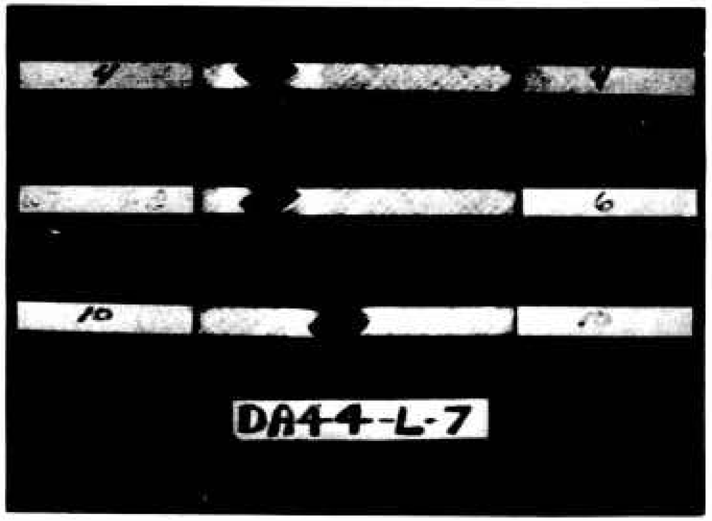
- Weakening of the adhesive bond at the doublers or cohesive failure.
- Incorrect positioning of test grips.
- Delamination causing a curling of the outer laminate layers which resulted in a cantilevering effect at the doublers.
- Variation of thermal expansion between specimen and metal doublers.
- Stress concentration factors at the doubler location.

The crossply specimens tested at room temperature generally experienced a typical shearing matrix failure in the fiber direction. The loading in shear appeared from inspection to be initiated simultaneously at the unsupported edges and to propagate to the midpoint of the laminate. Typical failures of this nature are exhibited in Figures 14 through 19. Tables IV and V list the failure mode observed on static compression and laminate tensile specimens. The examined specimens indicated no unusual behavior on fiber failures. However, the tensile specimen failure modes were observed by the preponderance of doubler failures.

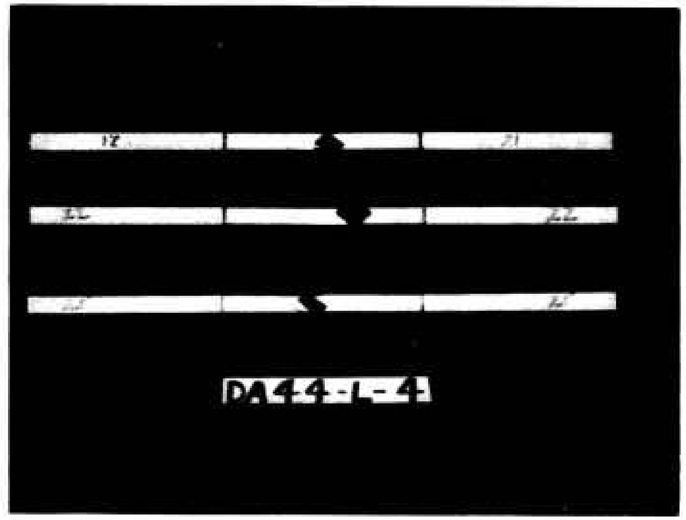
The majority of stress values for crossply laminates shown in Table VII are breaking strengths. The values recorded show an average distribution of 20,000 to 25,000 psi. The shear value for epoxy is approximately 8,000 psi. However, the matrix is assumed to be constrained by a factor of 1.5 x 8,000 psi or 12,000 psi. This value is approximately the ultimate tensile strength of the resin when fibers do not offer constraint in the axial direction. The 160°F temperature exposures had apparently very little effect on the strength of crossply laminates. However, at lower temperatures, the laminates did exhibit as expected, an increase of strength.

The unidirectional laminates such as XP251S and 1002S generally experienced the same failure pattern at all temperatures; that is, a combination of adhesive failure at the doublers and delamination. Further inspections revealed that the doublers generally were cantilevered probably due to an interlaminar shear load between the adhesive and outer layer.

The BP907-143S specimens had debonded at the doublers in the lower temperature regime. However, at room and 160°F temperature, the specimens had undergone a complete interlaminar

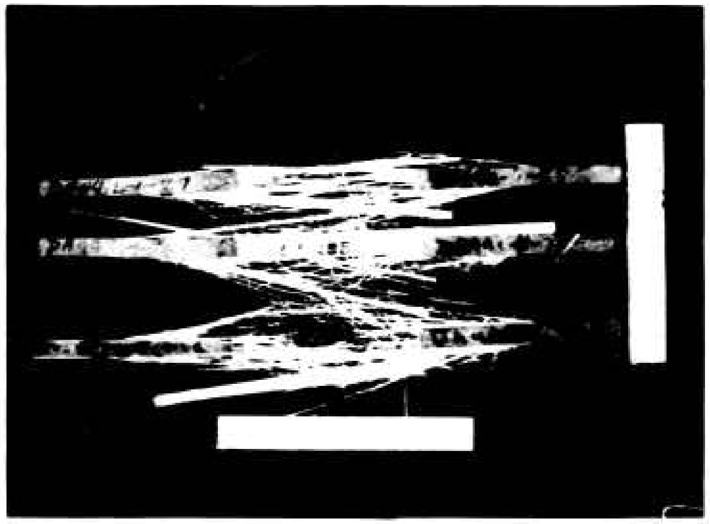


MATERIAL: XP251S CROSSPLY, (±45°), CURE A

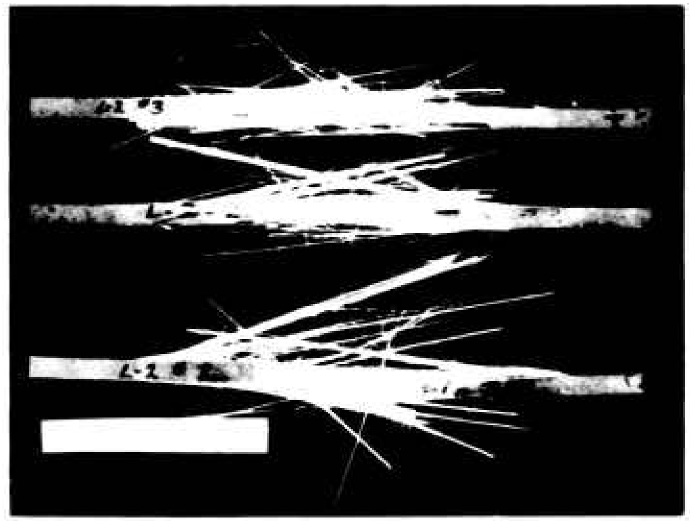


MATERIAL: 1002S CROSSPLY, (±45°), CURE B

Figure 14. Static Tensile Laminates Tested at Room Temperature (75°F).



MATERIAL: 1002S UNIDIRECTIONAL



MATERIAL: 1002S UNIDIRECTIONAL,

Figure 15. Static Tensile Laminates Tested at Room Temperature (75°F).

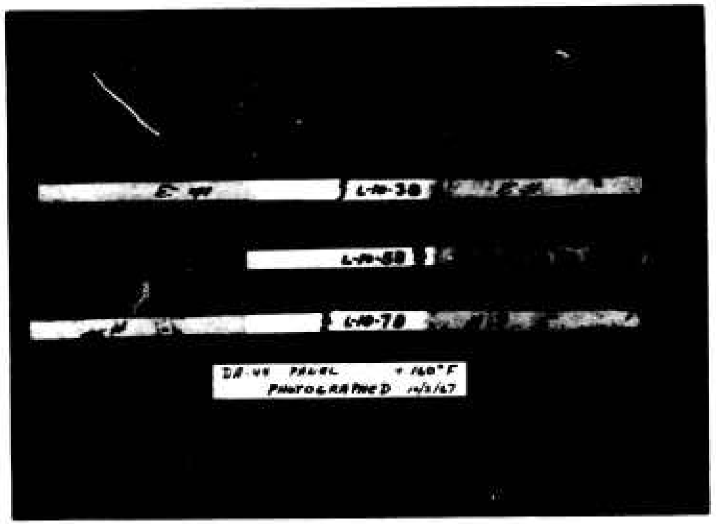
(A)

0° UNIDIRECTIONAL

(B)

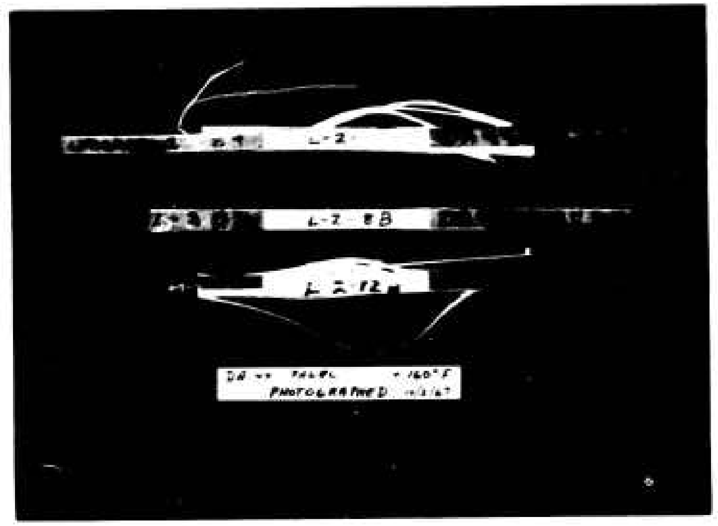
$\pm 45°$ CROSSPLY

Figure 16. Typical Failures of Laminates Tested at 160°F. (Note the Brooming Effect of Figure A)



(A)

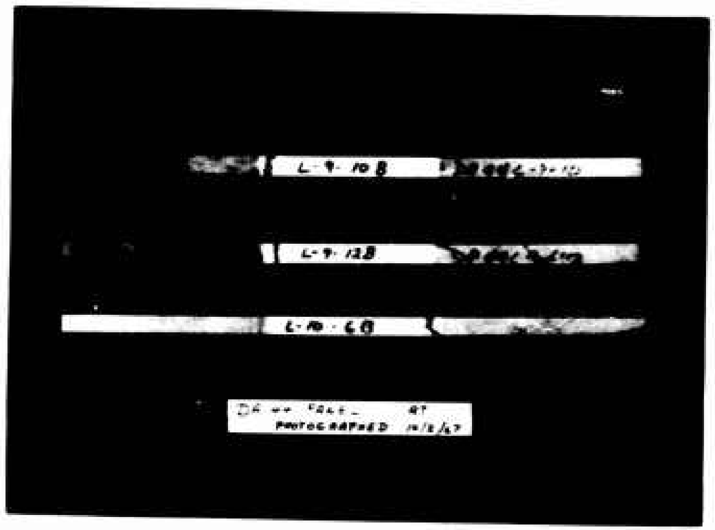
UNIDIRECTIONAL



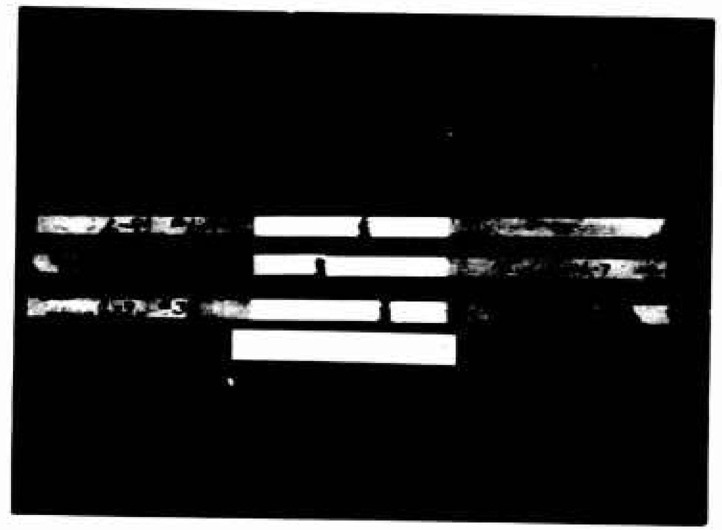
(B)

UNIDIRECTIONAL

Figure 17. Typical Failures of Laminates Tested at 160°F. (Note the Delamination of Figure B.)

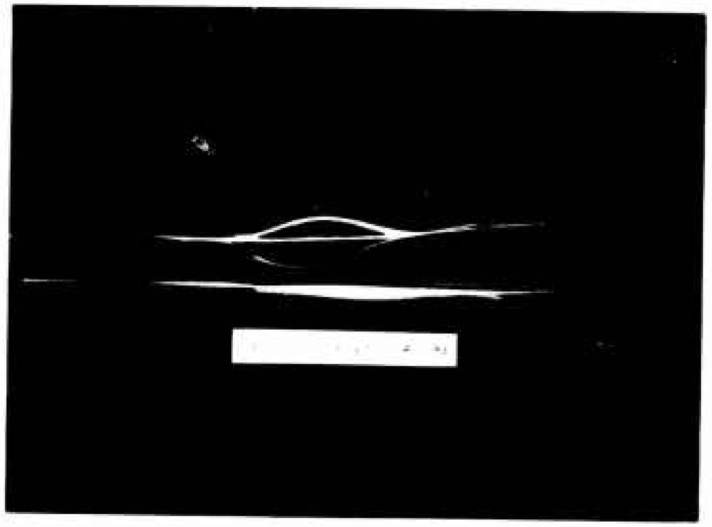


MATERIAL: BP907-143S UNIDIRECTIONAL OR 0° AT WARP (-65°F), CURE B

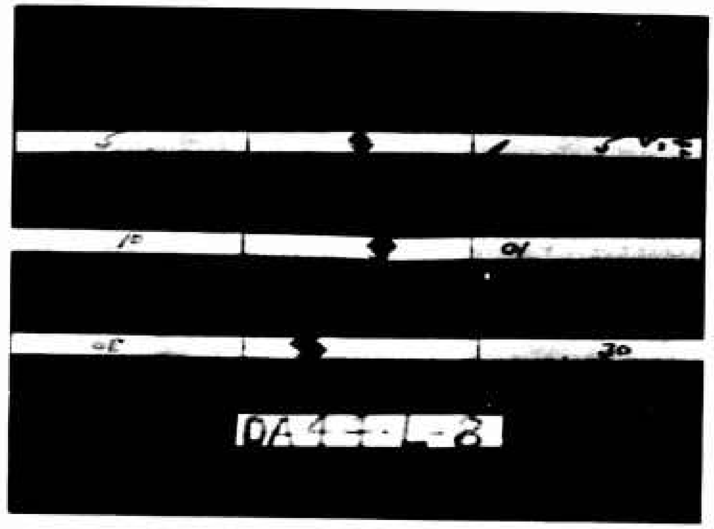


MATERIAL: BP907-143S UNIDIRECTIONAL OR 0° AT WARP (75°F), CURE B

Figure 18. Static Tensile Laminates Tested at Room Temperature and -65°F.



MATERIAL: XP251S UNIDIRECTIONAL (0°), CURE A



MATERIAL: XP251S CROSSPLY (±45°), CURE B

Figure 19. Static Tensile Laminates Tested at 160°F.

TABLE IV. SUMMARY OF LAMINATE COMPRESSION TEST FAILURE

Test Temp (°F)	Fiber Orientation (Degrees)	Laminate Material	Failure Modes
75	0	XP251S	1) Edgewise shear perpendicular to load axis 2) Partial specimen separation 3) No failure
		1002S	Same as XP251S, plus complete specimen separation
		BP907	1) Edgewise shear perpendicular to load axis 2) Edgewise shear at 45° to load axis 3) Partial specimen separation 4) Complete specimen separation 5) No failure
	±45	XP251S	Matrix fracture parallel to fiber direction
		1002S	Same as XP251S
		BP907	No test
75 *	0	XP251S	1) Edgewise shear perpendicular to load axis 2) Partial specimen separation 3) No failure
		1002S	Same as XP251S
		BP907	Complete specimen separation
	±45	XP251S	Matrix fracture parallel to fiber direction
		1002S	Same as XP251S
		BP907	No test

*Specimens conditioned in a condensing humidity chamber (100 percent humidity) at 120°F for 30 days and tested within 30 minutes at ambient temperature.

TABLE IV. CONTINUED

Test Temp (°F)	Fiber Orientation (Degrees)	Laminate Material	Failure Modes
160	0	XP251S	No failure
		1002S	1) Edgewise shear perpendicular to load axis 2) Double edgewise shear perpendicular to load axis 3) Partial specimen separation
		BP907	1) Double edgewise shear perpendicular to load axis 2) Partial specimen separation 3) No failure
	±45	XP251S	Matrix fracture parallel to fiber direction
		1002S	1) Matrix fracture parallel to fiber direction 2) Partial specimen separation
		BP907	No test
-65	0	XP251S	1) Edgewise shear perpendicular to load axis 2) Partial specimen separation
		1002S	Edgewise shear perpendicular to load axis
		BP907	Complete specimen separation
	±45	XP251S	Matrix fracture parallel to fiber direction
		1002S	Matrix fracture parallel to fiber direction 2) No failure
		BP907	No test

TABLE V. STATIC LAMINATE TENSILE FAILURE SUMMARY

Material	Fiber Direction	Temperature	Failure
XP251S	Unidirectional	*R.T.	1) Delamination of layers 2) Small percentage of fiber breaks 3) Debonding of adhesive at doublers 4) Matrix fracturing parallel to fibers
1002S	Unidirectional	R.T.	Same failure as XP251S
BP907-143S	0° at Warp	R.T.	1) Small percent of specimens debonded at doublers 2) Clean break at test specimen area with no evidence of matrix fracture
XP251S	Crossply	R.T.	Matrix fracturing at ±45° plane
1002S	Crossply (±45°)	R.T.	Same failure as XP251S - Crossply at R.T.
XP251S	Unidirectional	-65°F	Same as XP251S at R.T.
1002S	Unidirectional	-65°F	Same as 1002S at R.T.
BP907-143S	0° at Warp	-65°F	No failure; debonding of adhesive at doubler
XP251S	Crossply (±45°)	-65°F	Same as XP251S at R.T.
1002S	Crossply (±45°)	-65°F	Same as 1002S at R.T.
XP251S & 1002S	Unidirectional	160°F	Same as XP251S & 1002S at R.T.
BP907-143S	0° at Warp	160°F	Complete break; no matrix fracture
XP251S & 1002S	Crossply (±45°)	160°F	Same as XP251S & 1002S at R.T.

*R.T. = Room temperature

TABLE VI. STATIC SANDWICH FLEXURE FAILURE SUMMARY

Test Temp (°F)	Fiber Orientation (Degrees)	Facing Material	Failure Modes
160	0	XP251S	1) Failure in compression face 2) Edgewise shear 3) Shear failure in core due to wrinkling 4) Adhesive bond failure 5) Interlaminar shear failure
		1002S	1) Failure in compression face 2) Edgewise shear 3) Shear failure in core due to wrinkling
		BP907	1) Failure in compression face 2) Edgewise shear
	±45	XP251S	No Failure
		1002S	No Failure
		BP907 XP251S	No Failure
		BP907 1002S BP907	No Failure
-65	0	XP251S	1) Compression face debonding 2) Failure in compression face 3) Edgewise shear 4) Interlaminar shear 5) Shear failure in core due to wrinkling 6) Adhesive bond failure
		1002S	1) Shear failure in core due to wrinkling 2) Adhesive bond failure 3) Interlaminar shear
		BP907	1) Failure in compression face 2) Interlaminar shear 3) Edgewise shear 4) Adhesive bond failure
	±45	XP251S	No Failure
		1002S	No Failure
		BP907 XP251S	No Failure

TABLE VI. CONTINUED			
Test Temp (°F)	Fiber Orientation (Degrees)	Facing Material	Failure Modes
-65	±45	BP907 1002S BP907	No Failure
75	0	XP251S	1) Failure in compression face 2) Edgewise shear 3) Shear failure in core due to wrinkling 4) Adhesive bond failure 5) Interlaminar shear failure
		1002S	1) Failure in compression face by debonding 2) Adhesive bond failure 3) Interlaminar shear failure
		BP907	1) Failure in compression face 2) Edgewise shear 3) Interlaminar shear failure 4) Adhesive bond failure
	±45	XP251S	No Failure
		1002S	No Failure
		BP907 XP251S	No Failure
		BP907 1002S BP907	No Failure
75*	0	XP251S	1) Failure in compression face 2) Edgewise shear
	±45	BP907 XP251S	No Failure
		BP907 1002S BP907	No Failure
75**	0	XP251S	1) Failure in compression face 2) Edgewise shear 3) Shear failure in core due to wrinkling

TABLE VI. CONTINUED			
Test Temp (°F)	Fiber Orientation (Degrees)	Facing Material	Failure Modes
75**	±45	BP907 XP251S	No Failure
		BP907 1002S BP907	No Failure

*Weathered (See Table XVII for explanation)

**Artificially Weathered (See Table XVII for explanation)

separation with no visible evidence of matrix fracturing. The average tensile strength of BP907-143S had a range of 78.70 to 165.5 x 10^3 psi over the temperature and environmental range tested.

LAMINATE TESTING (DYNAMIC)

Dynamic fatigue tests were performed on 125 laminates utilizing a Sonntag SF-1 fatigue machine. A typical test setup is shown in Figure 20. The stress ratio was held to 0.10 for all tests except the room temperature specimens which were run at 0.05. The load ranged from a minimum of 2.45 $\pm$ 2.00 ksi to a maximum of 47.0 $\pm$ 38.5 ksi. All specimens were tested at -65°F, 75°F, or 160°F. The unidirectional specimens, including the 143S-style fabric, experienced few runouts at all test temperatures. The test data are dispersed over a cycle range of 1 x 10^4 to 6 x 10^6 cycles. The crossply laminates consistently failed because of amplitude increases, especially in the 160°F temperature range. The failures were attributed to the inability of the specimen crossply configuration to absorb the load. Various load inputs were tried in order to obtain meaningful data, but failures occurred frequently in a range less than a million cycles.

The test summary data and S-N curves are shown in Table XI. The S-N curves illustrated represent data from each test panel configuration used in the program.

Typical failures of the unidirectional and crossply specimens were generally the same as those experienced in the static tests (see Figures 21 and 22). Failures occurred frequently in the doubler area for unidirectional specimens accompanied by parallel matrix fiber fractures and a small percentage of fiber breaks (see Figure 23). The crossply failure was typical, with matrix fractures and complete specimen breaks occurring in the 45-degree fiber planes.

Figure 20. Typical Test Setup for Tension-Tension Fatigue Laminate Specimen.

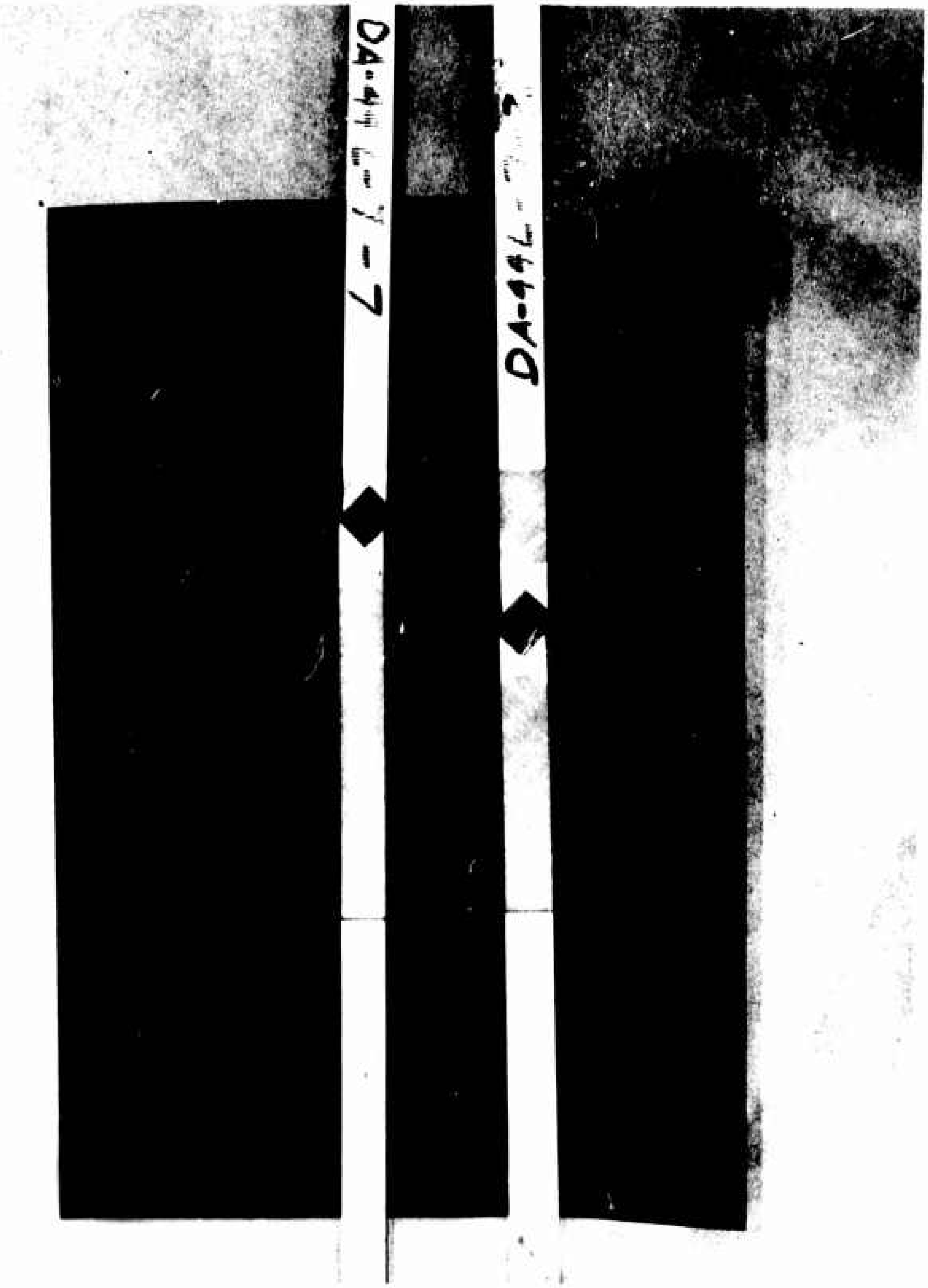


Figure 21. Crossply Tension-Tension Fatigue Laminate Failure, XP251S Scotchply Tested at -65°F.

Figure 22. Unidirectional Tension-Tension Fatigue Laminate Failure, XP251S Scotchply Tested at 160°F.

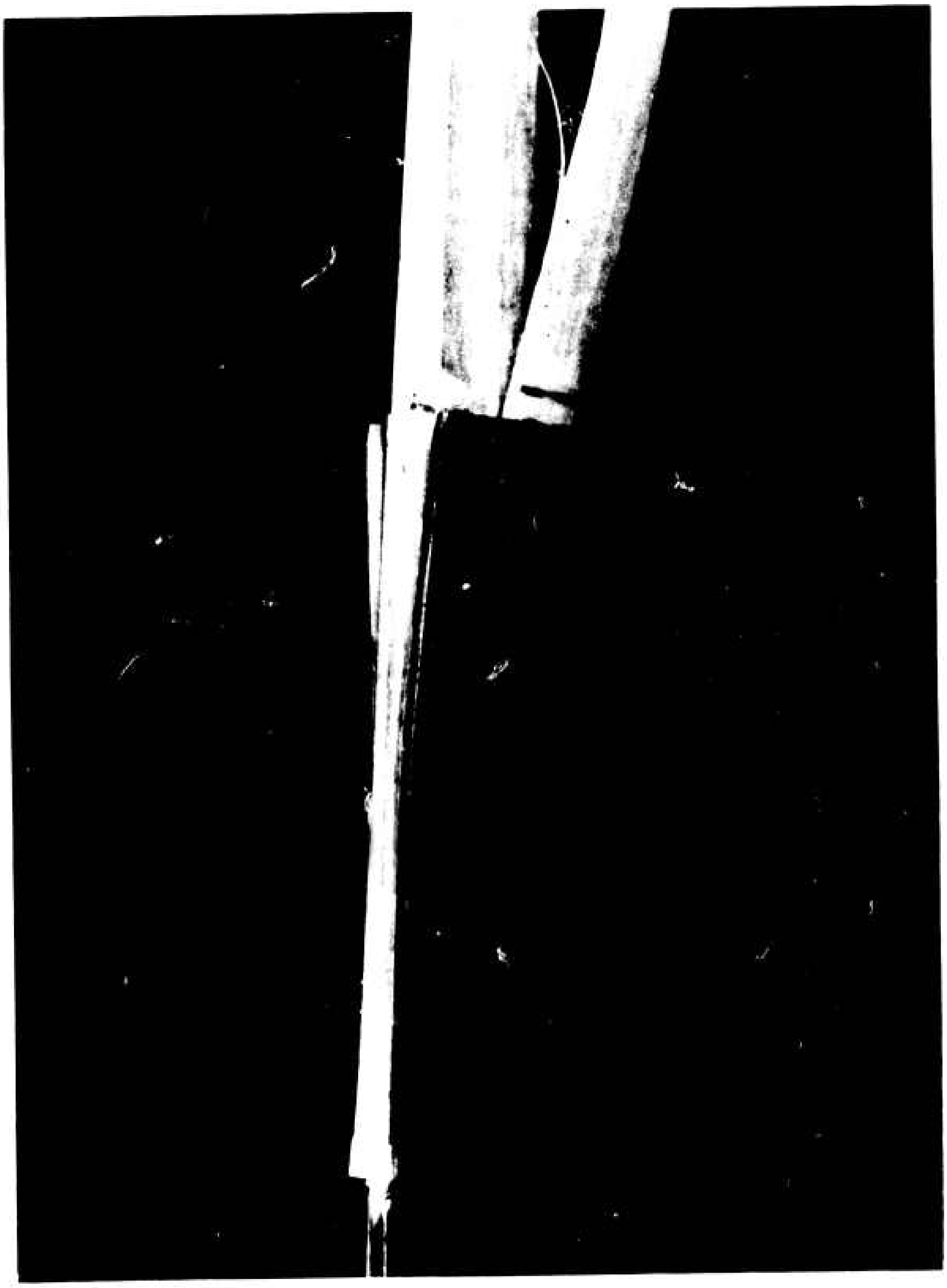


Figure 23. Typical Doubler Failure for Unidirectional Tension-Tension Fatigue Specimen.

SANDWICH BEAM FABRICATION

The sandwich panels fabricated for the static and dynamic tests in the program are shown in Table XV. The layup and fabrication procedures are illustrated in Figures 24, 25, 26, and 27. Two basic cures used for fabrication were as follows:

Cure A — 1 hour at 330°-340°F at 30 psig (Autoclave)

Cure B — 2 hours at 330°-340°F at 30 psig plus 16 hours at 280°F under vacuum pressure in an air-circulating oven

The general procedure for fabricating the test sandwich panels was as follows:

A typical 24-inch by 28-inch honeycomb core was fabricated and assembled as follows:

Step 1 — The core was stabilized with FM-37 core splice adhesive foam (modified epoxy) at both ends of the panel (see Figure 24).

- o The core was cleaned by degreasing in an air-circulating oven for a period of 45 minutes at a temperature of 225°F.

Step 2 — The prepreg fiber glass skins were laid up on the core using the following procedure:

- o The required facing material, core, and adhesive were assembled into a frame-type tool. The assembly was then covered with a caul plate similar to the one shown in Figures 3 and 4. The panel was then vacuum bagged and generally cured per the autoclave cycles shown in Table XV.

Static Flexure Test

Static flexure test of the sandwich beam specimens was conducted in order to determine the behavior of fiber glass sandwich beam facing materials subjected to two-point loading, as shown in Figure 28. An Instron Universal Testing Machine, Model 77C, was used to apply the load at a constant load rate of 0.05 inch per minute until failure of the specimen occurred. Load versus deflection plots were obtained from each specimen. The sandwich beam flexural modulus was determined by ordinary beam theory as follows:

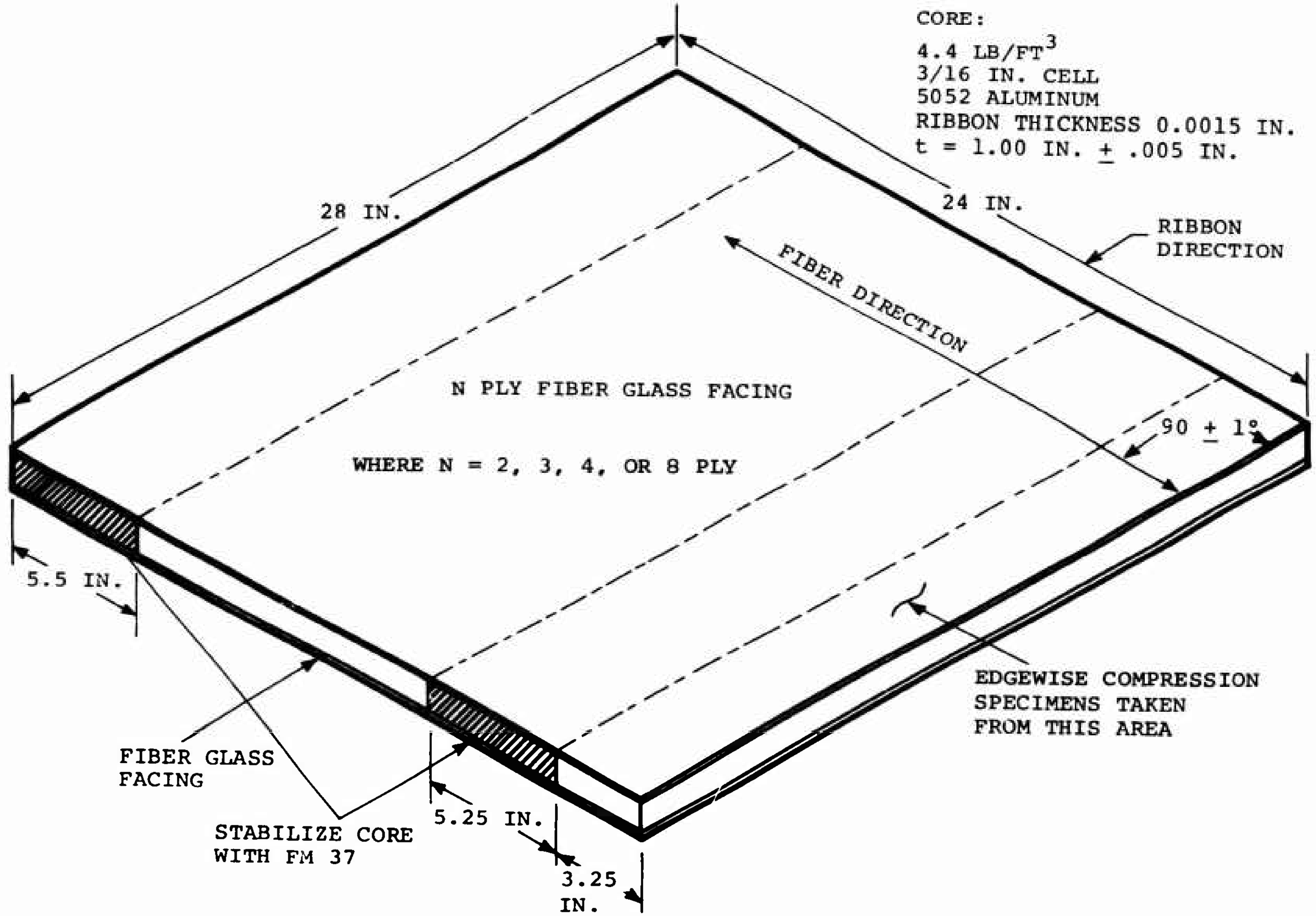
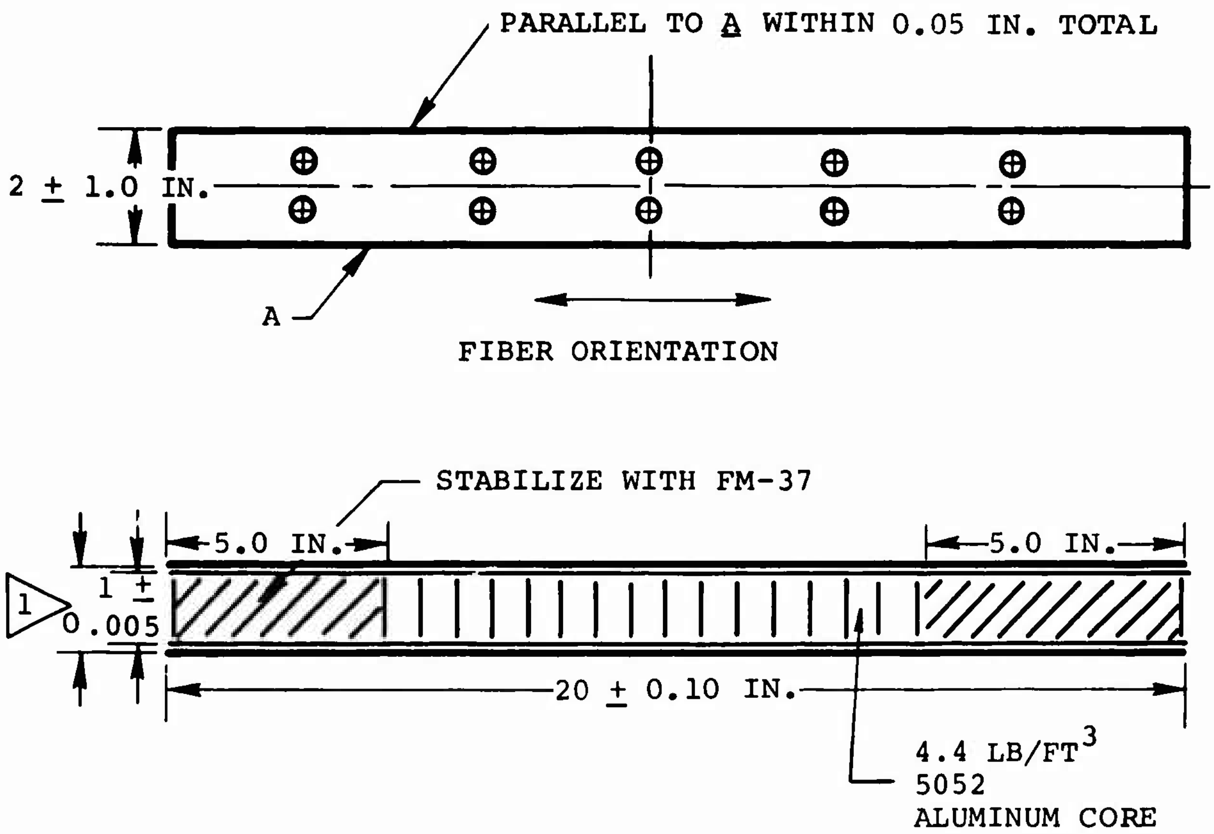


Figure 24. Unidirectional Sandwich Panel.



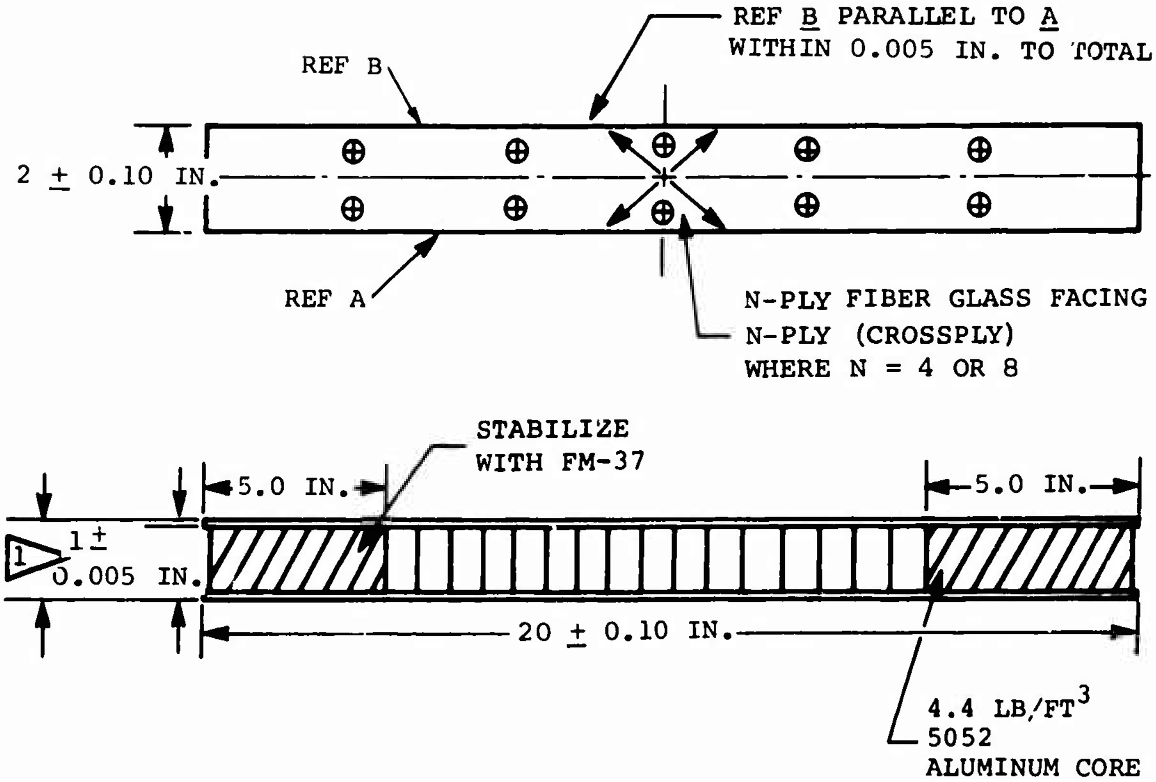
1 MEASURE THICKNESS IN 10 PLACES (⊕)

MAXIMUM AND MINIMUM SHALL NOT VARY BY MORE THAN 0.05 INCH

* MAXIMUM SPECIMEN BOW SHALL NOT EXCEED 0.003 INCH

* ALL EDGES SHALL BE SQUARE AND FREE FROM BURRS, NICKS, GOUGES, RESIN CRACKS, FRAYED FIBERS, AND DELAMINATIONS

Figure 25. Unidirectional Sandwich Specimen.



1 MEASURE THICKNESS IN 10 PLACES (⊕)

MAXIMUM AND MINIMUM SHALL NOT VARY BY MORE THAN 0.05 INCH

* MAXIMUM SPECIMEN BOW SHALL NOT EXCEED 0.05 INCH

* ALL EDGES SHALL BE SQUARE AND FREE FROM BURRS, NICKS, GOUGES, RESIN CRACKS, FRAYED FIBERS, AND DELAMINATIONS

Figure 26. Sandwich Specimen ±45 Degree Crossply Fiber Glass Facings.

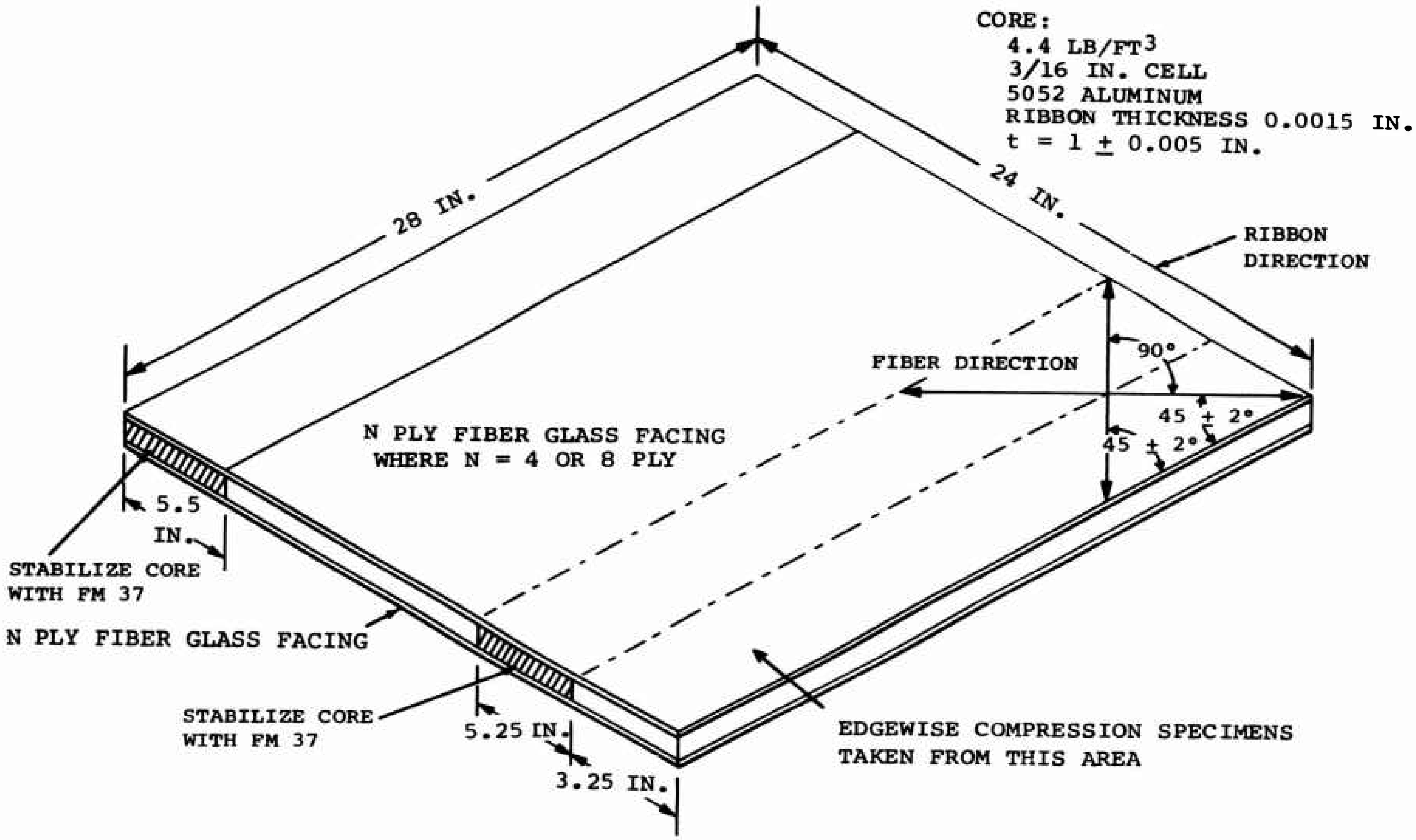


Figure 27. Crossply (±45 Degree) Fiber Glass Sandwich Panel.

$$E_B = \frac{\Delta P}{\Delta Y} \quad \frac{a_N\,(3L_N^2 - 4a_N^2)}{24I}$$

where $\frac{\Delta P}{\Delta Y}$ = change in load versus change in deflection at the beam midspan, lb/in.

b = width of sandwich beam, inches

c = core thickness, inches

d = total thickness of sandwich beam specimen, inches

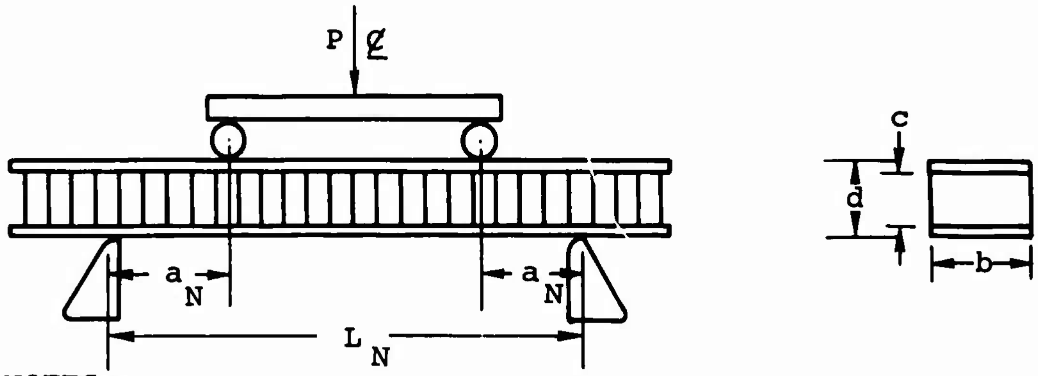
L_N = distance between sandwich reaction points, inches

a_N = 1/4 L_N

I = moment of inertia = $\frac{b}{12}(d^3 - c^3)$, in.^{4}

The results of the sandwich beam flexure tests are shown in appropriate engineering formats in Table IX. In addition, Table IX includes a description of testing environments, processing cures, and the type of failure exhibited by the specimen.

Figure 29 shows a sandwich beam undergoing a static flexure test at room temperature. Figure 30 shows a sandwich beam undergoing static flexure test at a controlled temperature of -65°F.



NOTES:

Where the Subscript N = 1, 2
L_1 = 16 Inches
L_2 = 19 Inches
a_1 = 6 Inches
a_2 = 8.5 Inches

Figure 28. Static Sandwich Beam Test Load Arrangement.

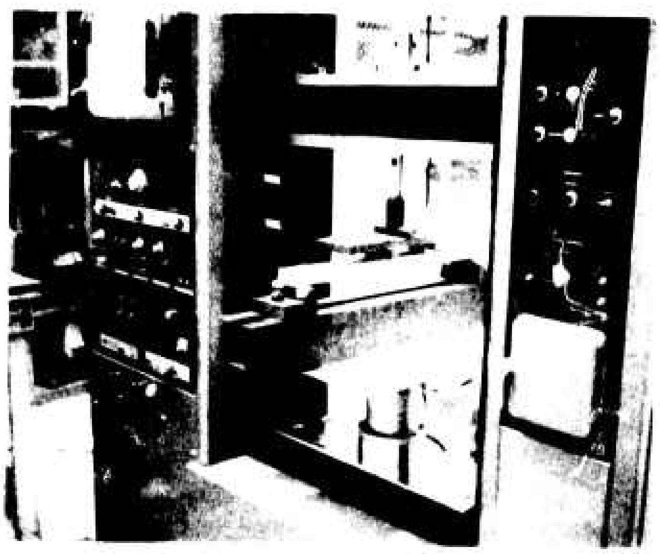


Figure 29. Sandwich Beams Undergoing Two-Point Loading Flexure Test at Room Temperature.

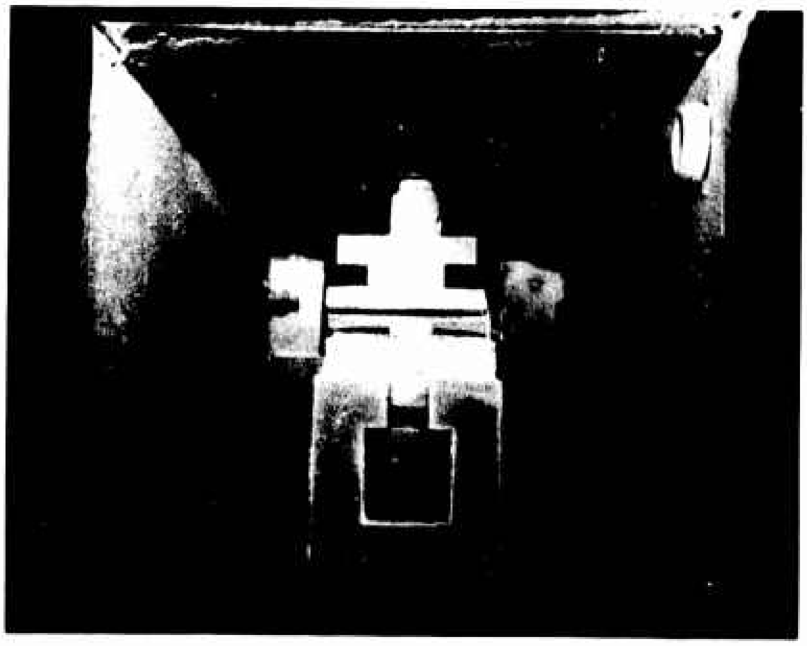


Figure 30. Sandwich Beam Undergoing Load-Deflection Test at Controlled Temperature of -65°F.

The sandwich facing strength was determined by the following method:

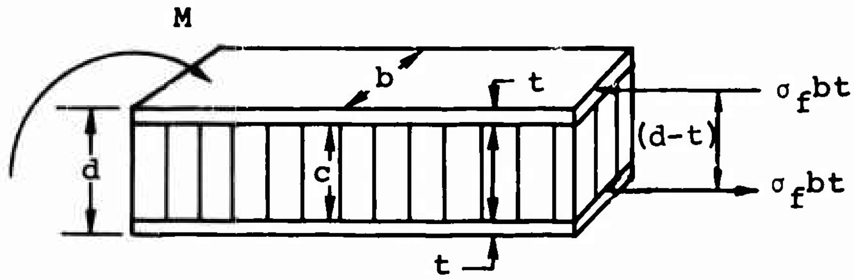


Figure 31. Static Equilibrium Loading of Sandwich Beam.

Assume that the axial loads and applied moment are distributed as shown in Figure 31. Then, according to static equilibrium, the facing stress is:

$$\sigma_f = \frac{M}{bt(d-t)} = \frac{M}{bt(t+c)}$$

where σ_f = facing stress, psi

t = facing thickness (either skin), in.

M = applied moment, in-lb.

Table VI illustrates the general mode of failure of all the static beams tested. The crossply specimens deflected generally at the midspan location with no indication of a failure either in the tension or compression face.

One failure mode experienced by the unidirectional beams was an edgewise skin shear near the inboard end of the stabilized core. The failure may have been caused by transverse shear forces introduced by the applied bending moment. These forces are assumed to be resisted by the combination of core and facing materials. However, the core assumes the heavier load, and will fail if the shear load exceeds the core strength capabilities or proportional limits of the material. When the

core begins to fail, the modulus of rigidity is reduced and the load in shear is transferred to the facings resulting in an edgewise skin shear failure.

SANDWICH BEAMS (DYNAMIC)

Fiber glass flexure sandwich beams were tested on a Sonntag S-1 Fatigue Test Machine. The test objective was to determine the relative beam flexure fatigue characteristics for fiber glass sandwich beams fabricated with woven and unwoven pre-preg epoxy S-glass skins and aluminum core. Conditioned specimens were tested at temperatures of -65°F and 75°F and run at stress ratios of 0.10.

The panel layups and cure sequences for the skins are identical to the static specimens shown in Table XV. The beams were dimensioned as shown in Figures 24, 25, 26, and 27. The sandwich beam specimen fatigue test arrangement is shown in Figure 32, and the test setup is shown in Figure 33. All the applied loads were randomly selected to provide a spread of data within desired life cycles. However, failures such as delaminations, debonding of the sandwich skins from the core, and the inability of the specimen to retain the applied loads (i.e., amplitude failure) were common occurrences which resulted in aborting the tests. The crossply specimens at all test temperatures failed by deformation at low cycles (less than a million cycles) because of amplitude problems. The only explanation available for this phenomenon may be the weakness associated with the matrix, which offers no constraining factor due to the interaction forces between the ply layers. The conditioned specimens such as the 120-degree wet-soak specimens had generally experienced a low cycle life (less than a million cycles).

COMPRESSIVE SANDWICH TESTS (EDGEWISE COMPRESSION)

A number of conditioned and unweathered specimens were tested to determine sandwich-constructed compressive properties at temperatures of -65°F, 75°F, and 160°F. The test procedure used was Federal Standard Method 1021. All specimens were tested on an Instron Universal Machine at a crosshead speed of 0.05 inch per minute. The specimens were loaded in the direction parallel to the core ribbon. The results of the tests are shown in Table X. The compressive strength was calculated using the following expression:

$$\sigma_c = \frac{P}{2tb} ,$$

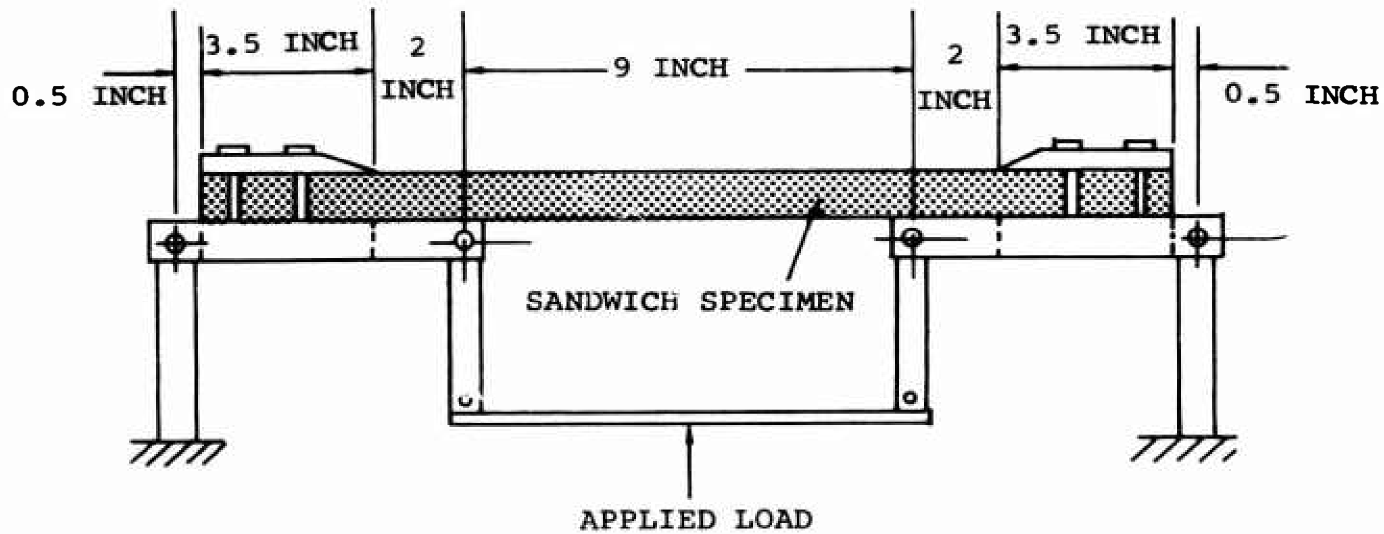


Figure 32. Sandwich Beam Fatigue Test Arrangement.

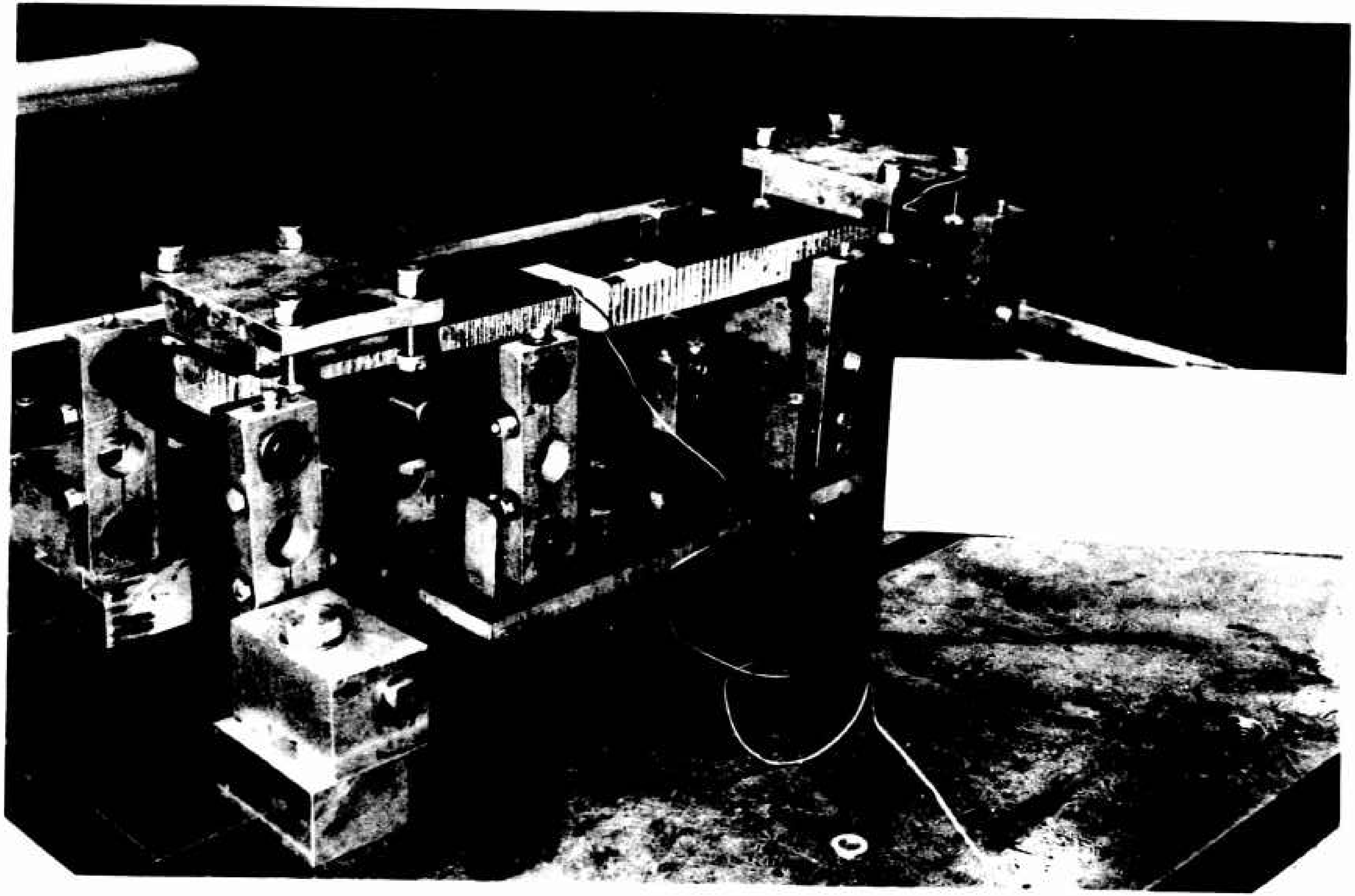
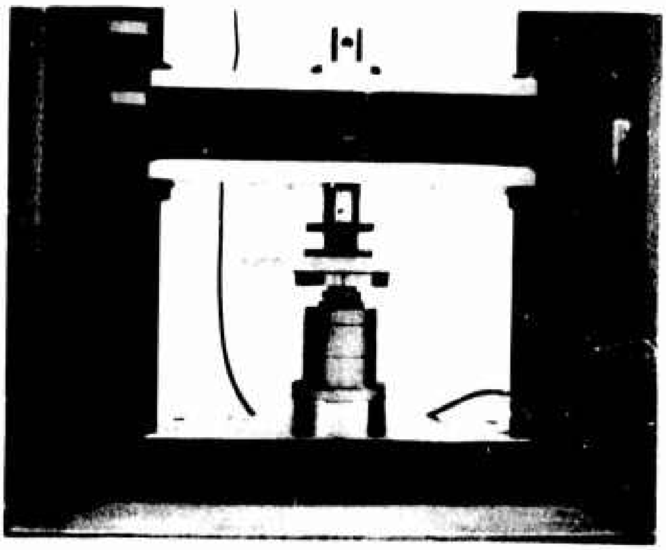


Figure 33. Fiber Glass Sandwich Beam Fatigue Test Setup (Typical).

where σ_c = compressive strength, psi

P = applied load, lb

The majority of failures were of the matrix fractures type accompanied by a slight percentage of delaminations. The unidirectional specimens demonstrated, as expected, strength in the lower temperature regime and weakness in the higher. The weathered and artificially conditioned specimens experienced very little change in strength in comparison to unconditioned specimens tested at room temperature. Figure 34 shows a sandwich beam specimen undergoing a compression test at room temperature.



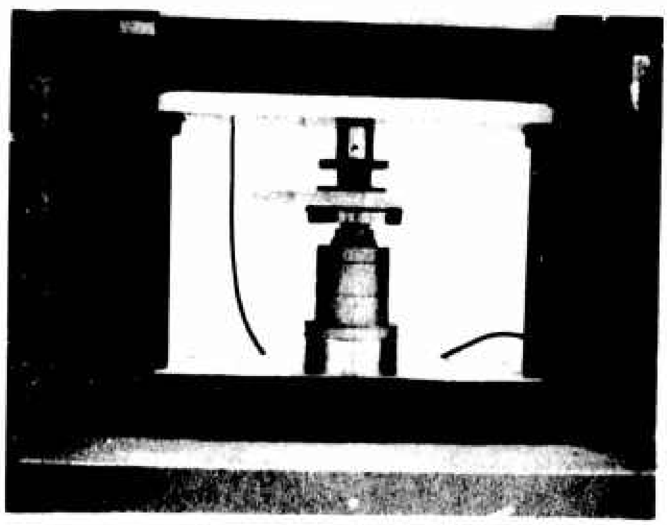


Figure 34. Sandwich Beams Under Loading of Edgewise Compression at Room Temperature.

STATIC AND FATIGUE TORSION TUBE SPECIMEN FABRICATION

Materials:

1) Scotchply (1002S and XP251S prepreg)

2) BP907-143S (epoxy resin. 143-style S-glass fabric)

3) Silicone rubber seamless tubing

4) 828 epoxy resin and curing agent diethylenetriamine (DTA)

5) 181 Fabric - Volan A. finish

Fabrication Procedure

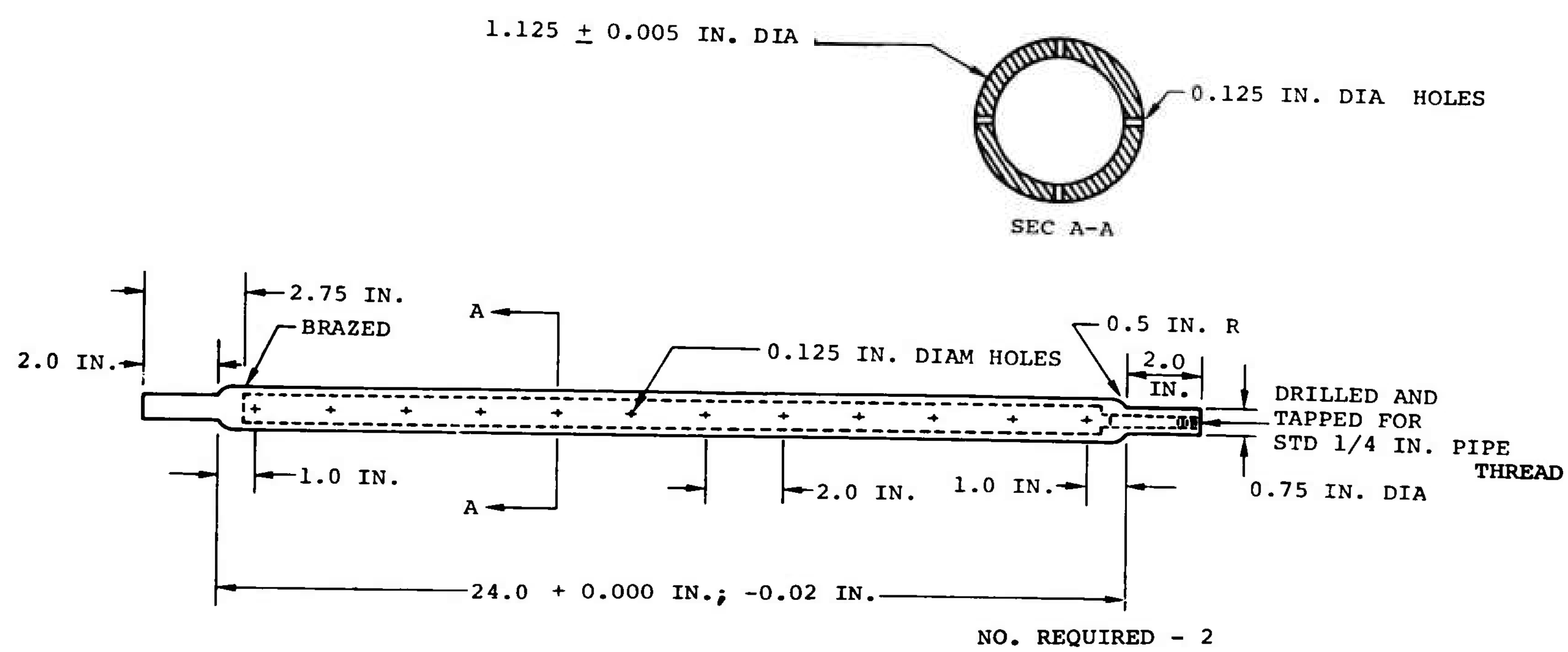
The tubes were fabricated from Scotchply XP251S and 1002S unidirectional (epoxy resin) prepregs and BP907-143S fabric prepreg. The unidirectional materials were wound at wrap angles of zero degrees and ±45 degrees, whereas the 143 fabric warp was wrapped at ±45 degrees, all relative to the tube axis.

The mandrel used during the fabrication of tube specimens met the requirements shown in Figure 35. Figures 36 and 37 illustrate the tube tool and die assembly and the relationship of the mandrel to the male and female portions of the tube and mold assembly. The tool surfaces were cleaned with acetone and treated with Garan 225 release agent. The mandrel was then wrapped with Mylar film to insure proper presizing of the fiber glass layers. Finally, the mandrel was covered with a seamless silicon tube or boot and covered with a Teflon film.

Figures 38, 39, and 40 show the configurations of the tube specimens. The tubes were wrapped as follows:

Material	*Wrap Angle
1002S	Zero degrees
XP251S	±45 degrees
BP907-143S	±45 degrees

*Wrap angle relative to tube longitudinal axis.



<u>MATERIAL</u>: 0.062 IN. WALL 2024-T3 ALUM TUBE - 2024-T3 ALUM ROUND STOCK BRAZED ON ENDS OF TUBE AND TURNED DOWN TO SIZE

Figure 35. Mandrel for 1.5-Inch Tubing Mold.

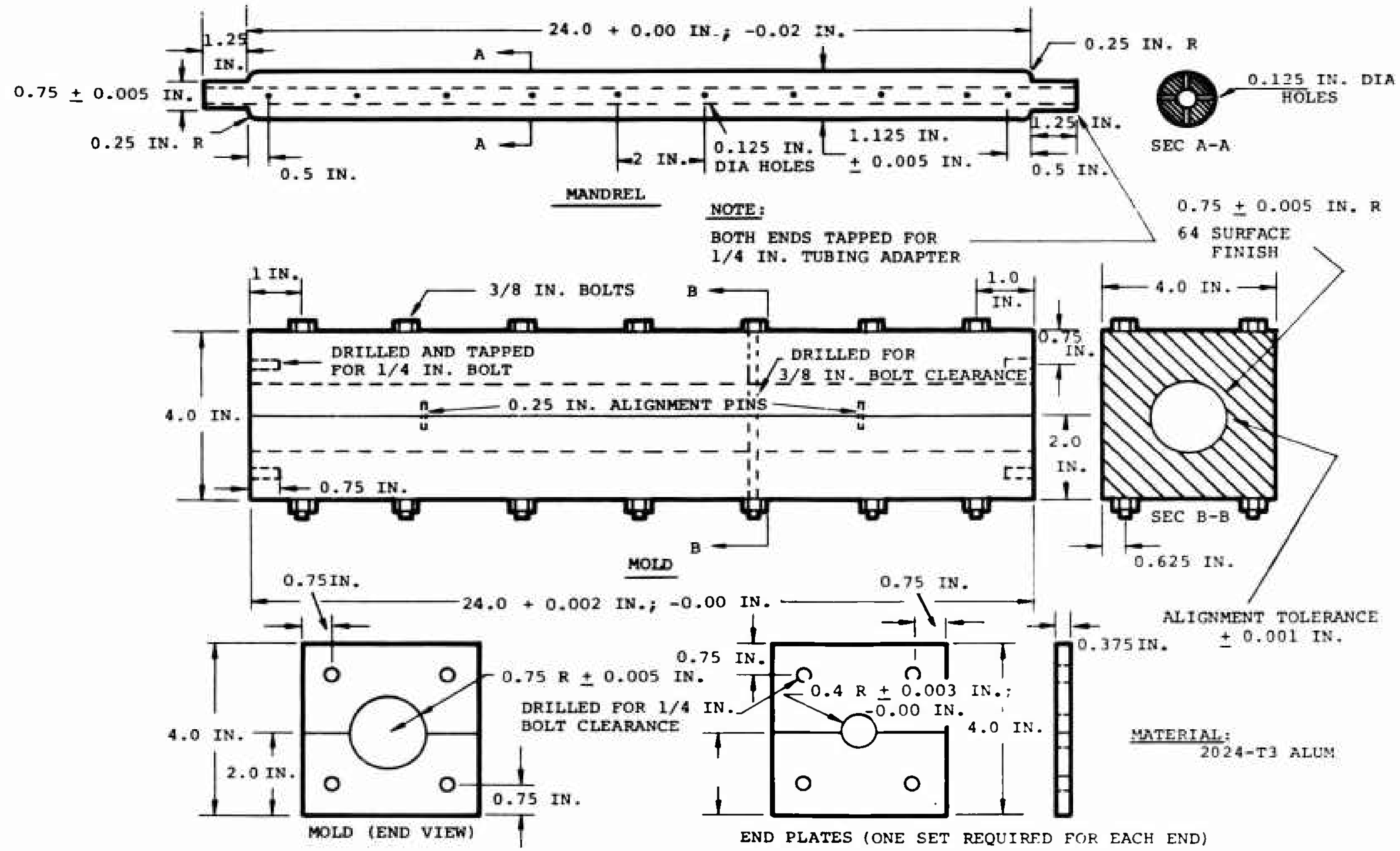
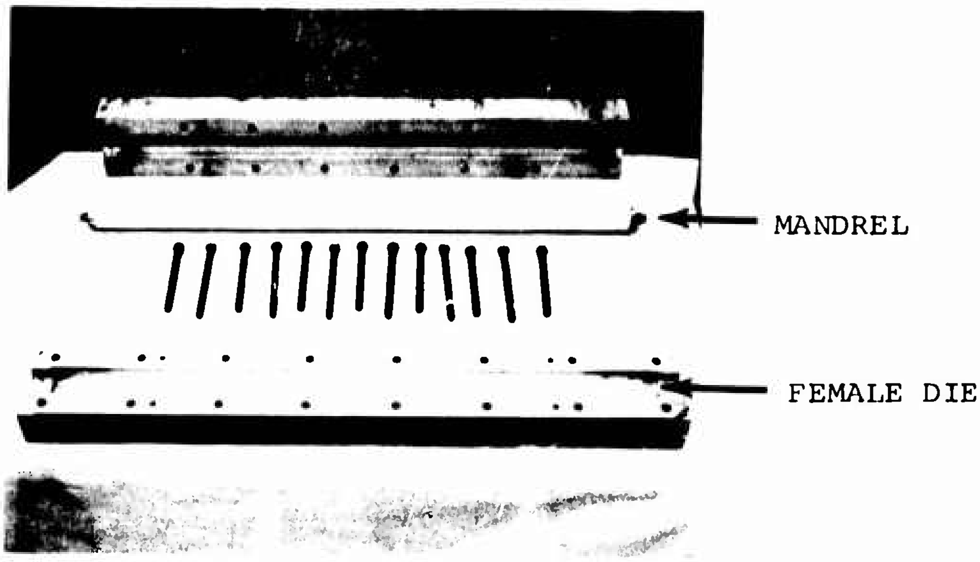
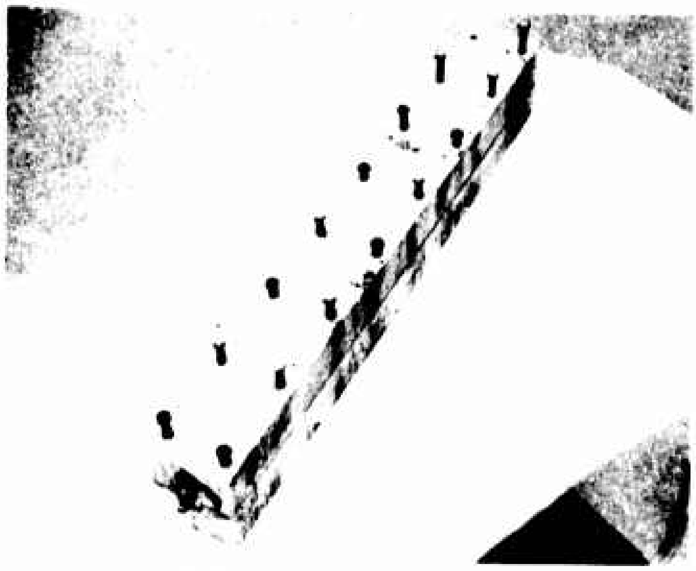


Figure 36. Tubing Mold.



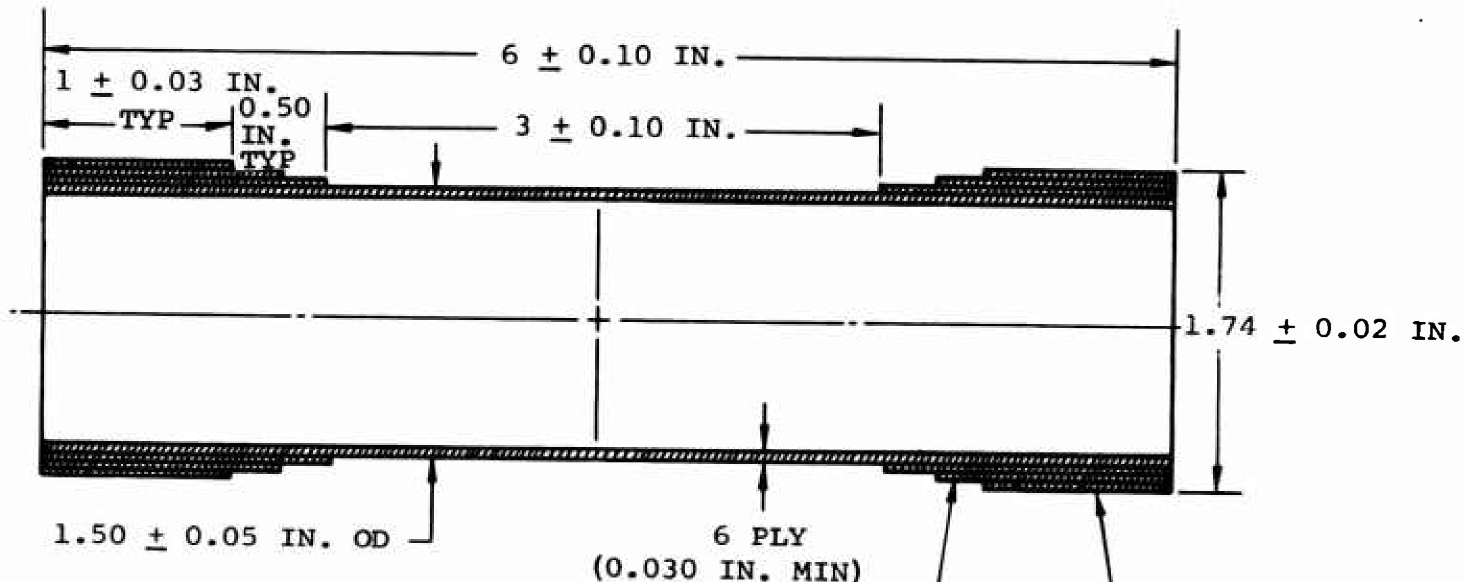
TUBE TOOLING



TUBE MOLD ASSEMBLY

Figure 37. Torsional Tube Specimen Tooling.

ALL FIBERS SHALL BE HELD WITHIN ± 2° OF SPECIFIED ANGLE OF WRAP



FIBER ORIENTATION

*FIBERS SHALL BE ORIENTED IN THE FOLLOWING ORDER

+45°, -45°, +45°, -45°, +45°, -45°

*WRAP ANGLES RELATIVE TO TUBE AXIS

Figure 38. Crossply (±45 Degree) Torsion Tube Specimen.

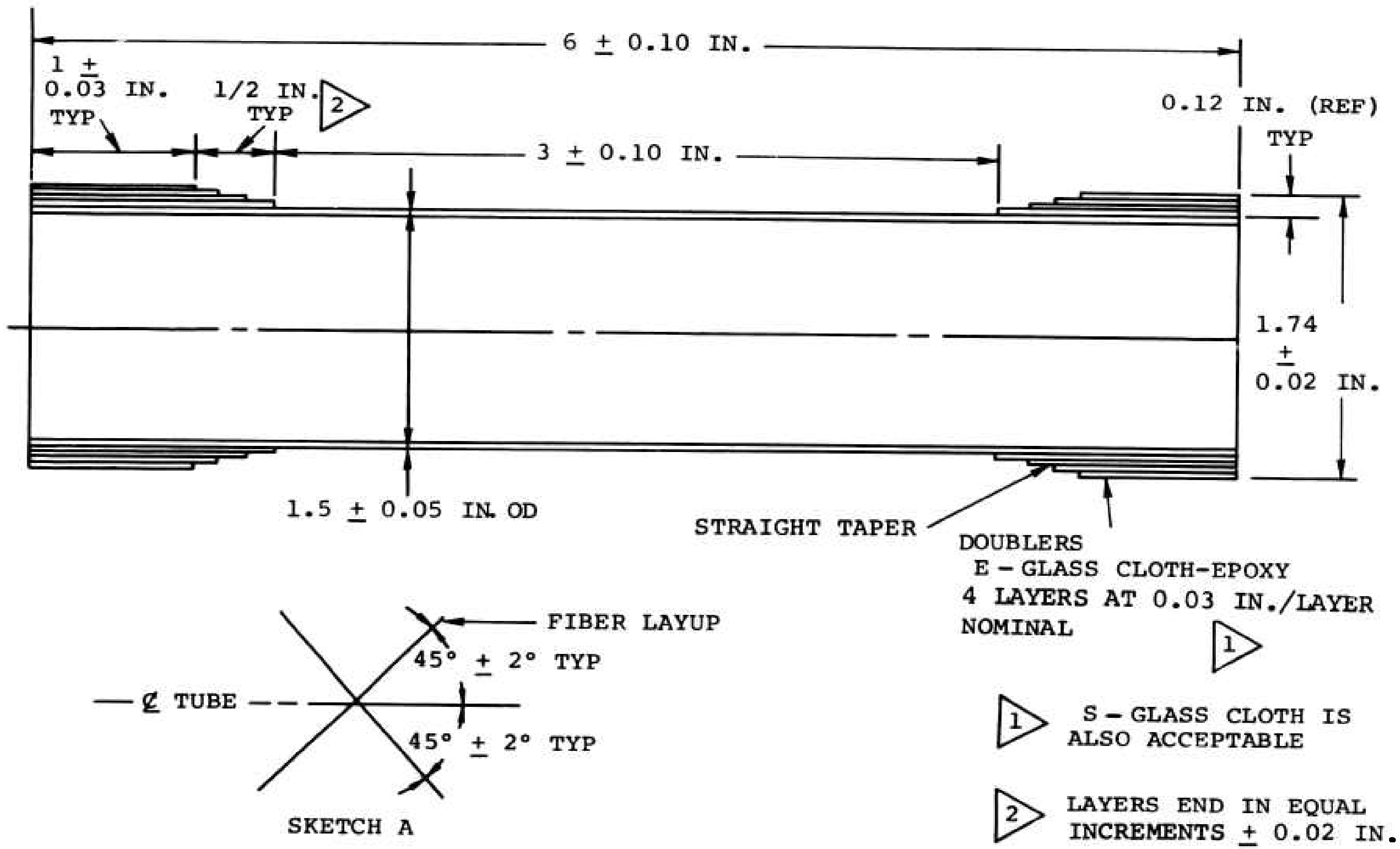


Figure 39. Fiber Glass Tube Configuration.

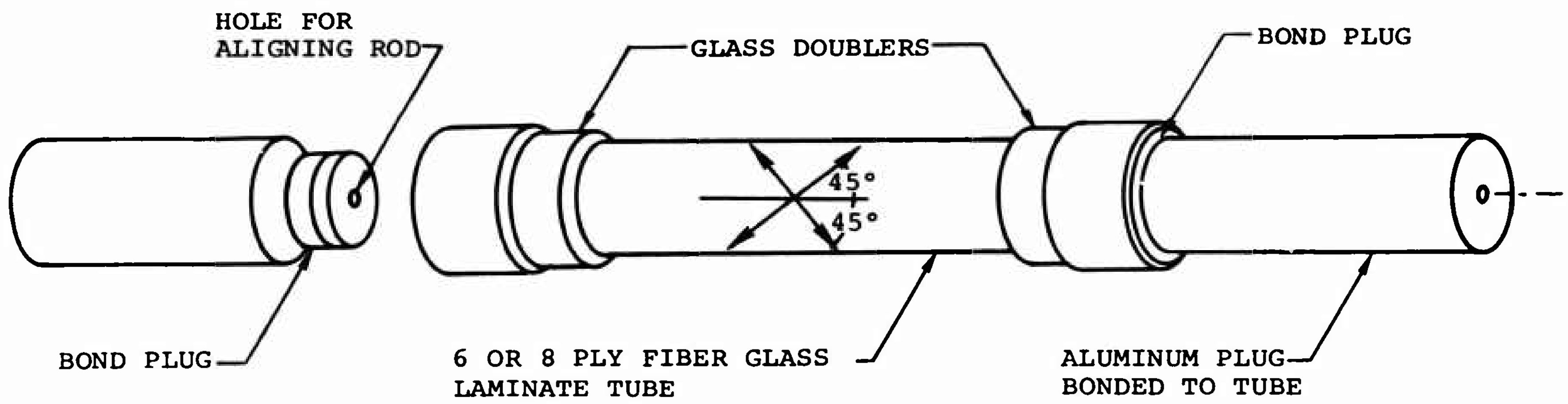


Figure 40. Fiber Glass Torsion Tube Specimen with Aluminum Plug-Grips.

Upon completion of each ply wrap, a measurement was made to the outer tube perimeter to insure thickness tolerances. The tube, after it was wound, was then placed in a female aluminum mold which was prepared with Garan 225 release agent. The mold was assembled, wrapped with a bleeder cloth and vacuum bagged, and then placed in an autoclave and cured per the following cycle:

Material	Step A	Step B	Step C
XP251S and 1002S	85 psig 280°-290°F 1 Hour, Autoclave	85 psig 330°-340°F 1 Hour, Autoclave	
BP907-143S	85 psig 175°-185°F 1/2 Hour, Autoclave	85 psig 280°-290°F 1/2 Hour, Autoclave	85 psig 330°-340°F 1/2 Hour, Autoclave

NOTES:

1) All tubes were exposed to a 16-hour postcure at 280°-290°F under vacuum pressure.

2) All unidirectional specimens were equipped with fiber glass doublers as shown in Figure 40.

3) Aluminum plug extensions were bonded on each end of the tube as shown in Figure 40. This procedure insured the necessary gripping for the specimens during the test procedure.

TORSION TUBE TEST (STATIC AND DYNAMIC)

Twenty-seven tubes were statically tested on a Sonntag machine to complete failure. The test setup is illustrated in Figures 41 and 42. A hydraulic ram delivers the required load through a load cell onto a connecting torque arm. As the specimen rotates, measurements of torque load versus angular rotation are recorded with the aid of dial indicators. The fatigue specimens (approximately 18) were tested on a SF-1 Sonntag machine using the same test setup for the static tube arrangement (see Figure 43).

The torsional strength properties for both fatigue and static tests are shown in Table XIII. Torsional stiffness was obtained by utilizing typical static calibration curves from the test plot, measured at room temperature, shown in Figures 44, 45, and 46. The tube stiffness was calculated using the following expression:

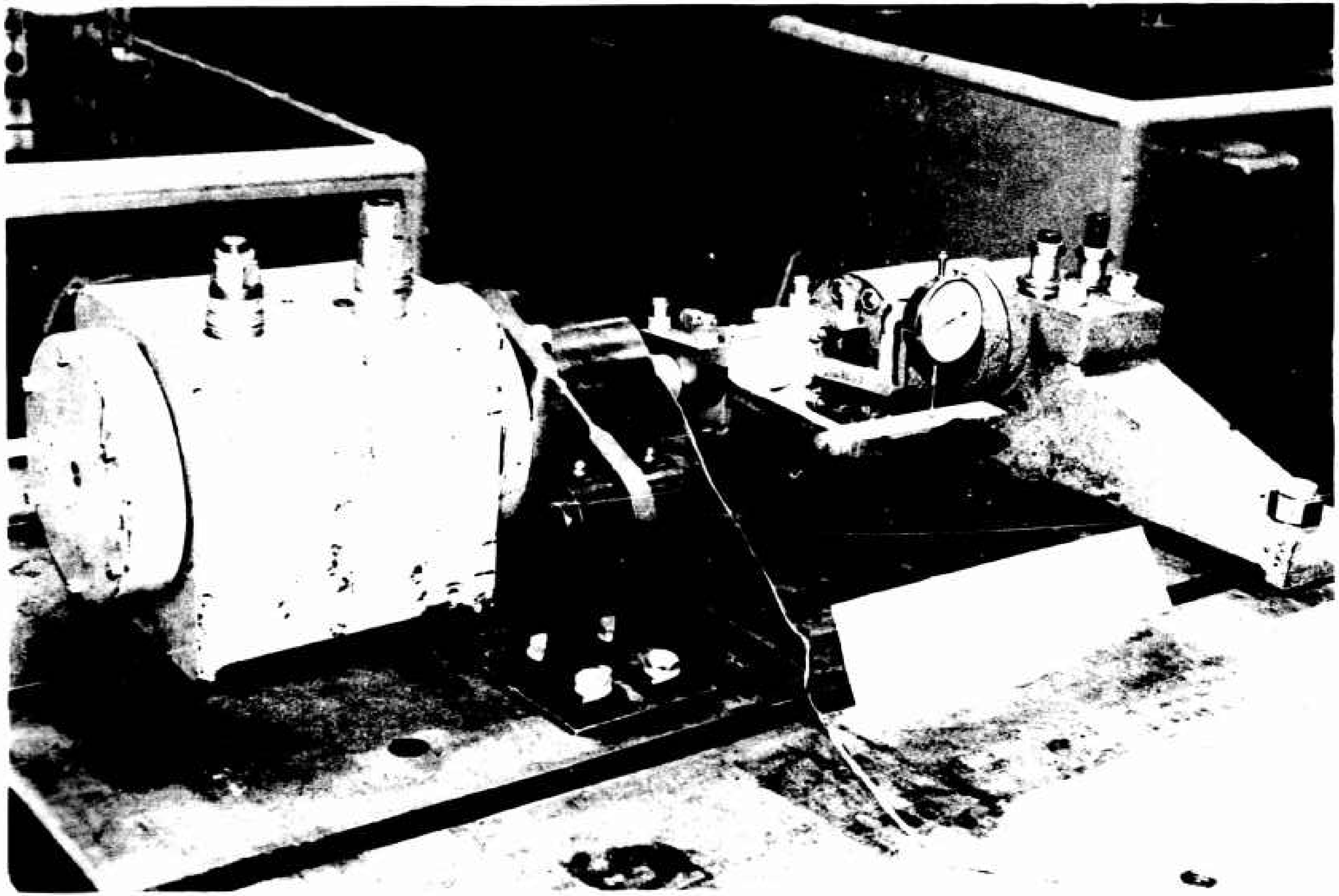


Figure 41. Static Calibration Setup for Fiber Glass Torsion Tubes Tested at Room Temperature.

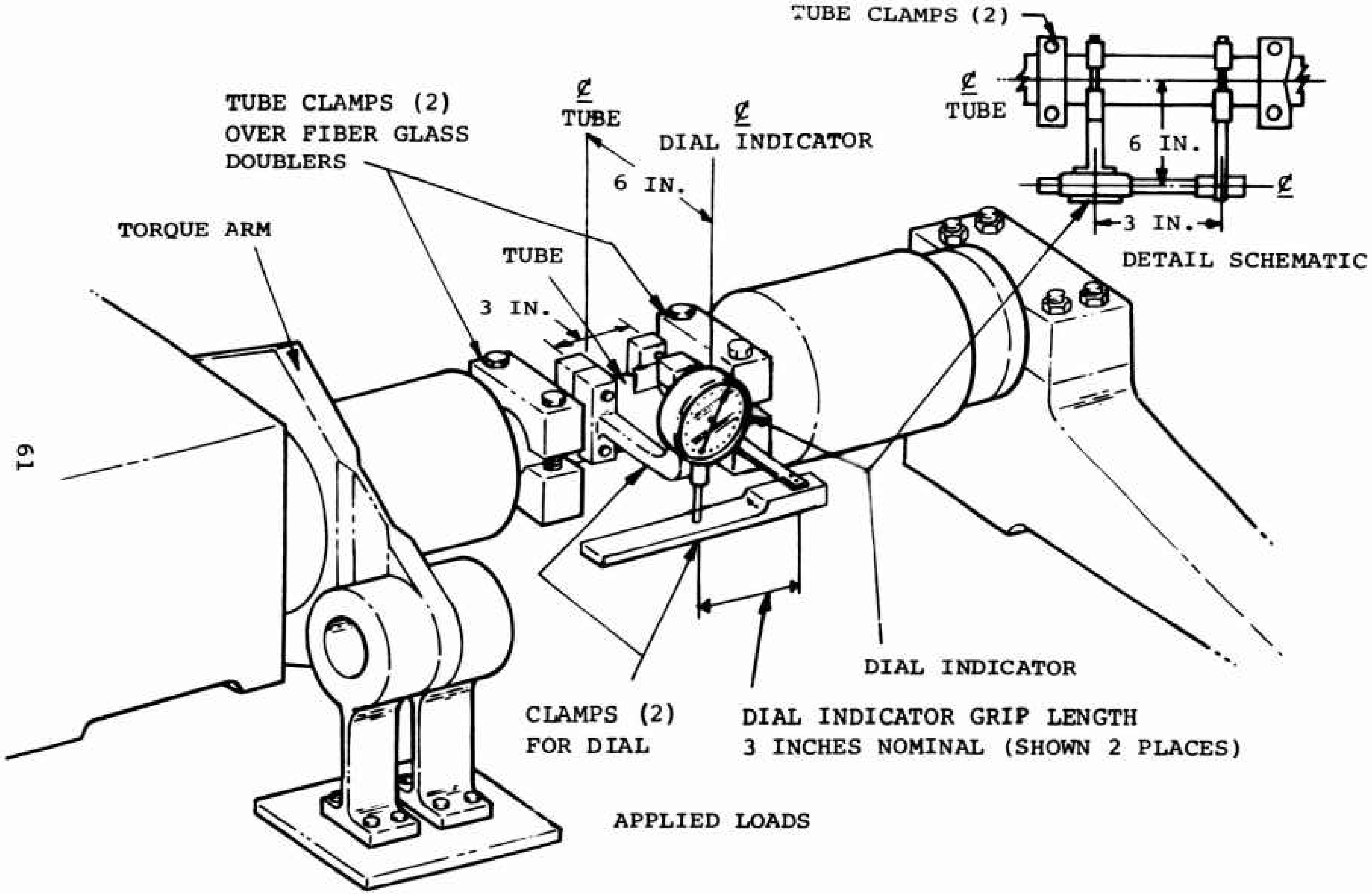


Figure 42. Fiber Glass Static Torsion Tube Test Setup.

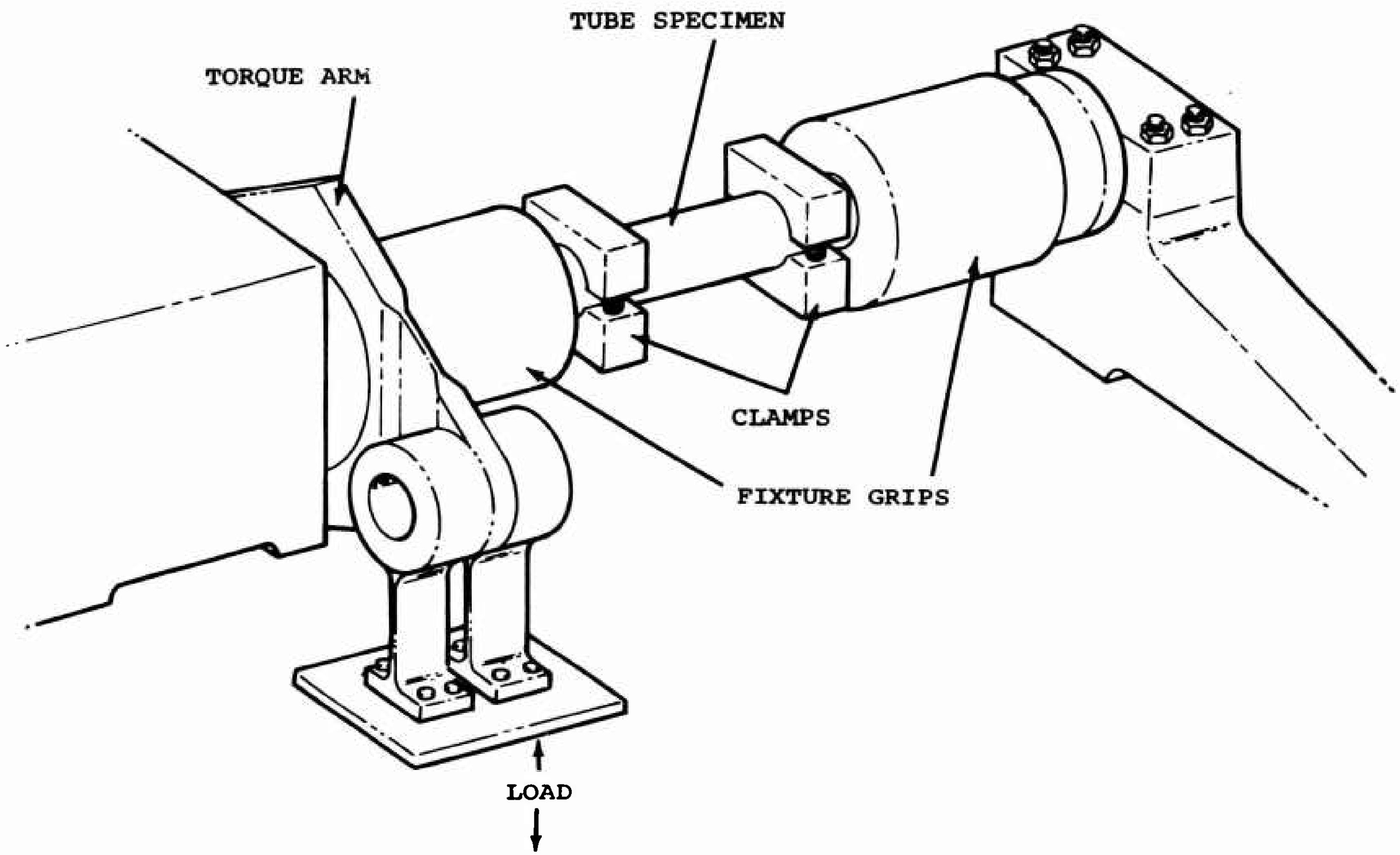


Figure 43. Fiber Glass Static Torsion Tube Setup.

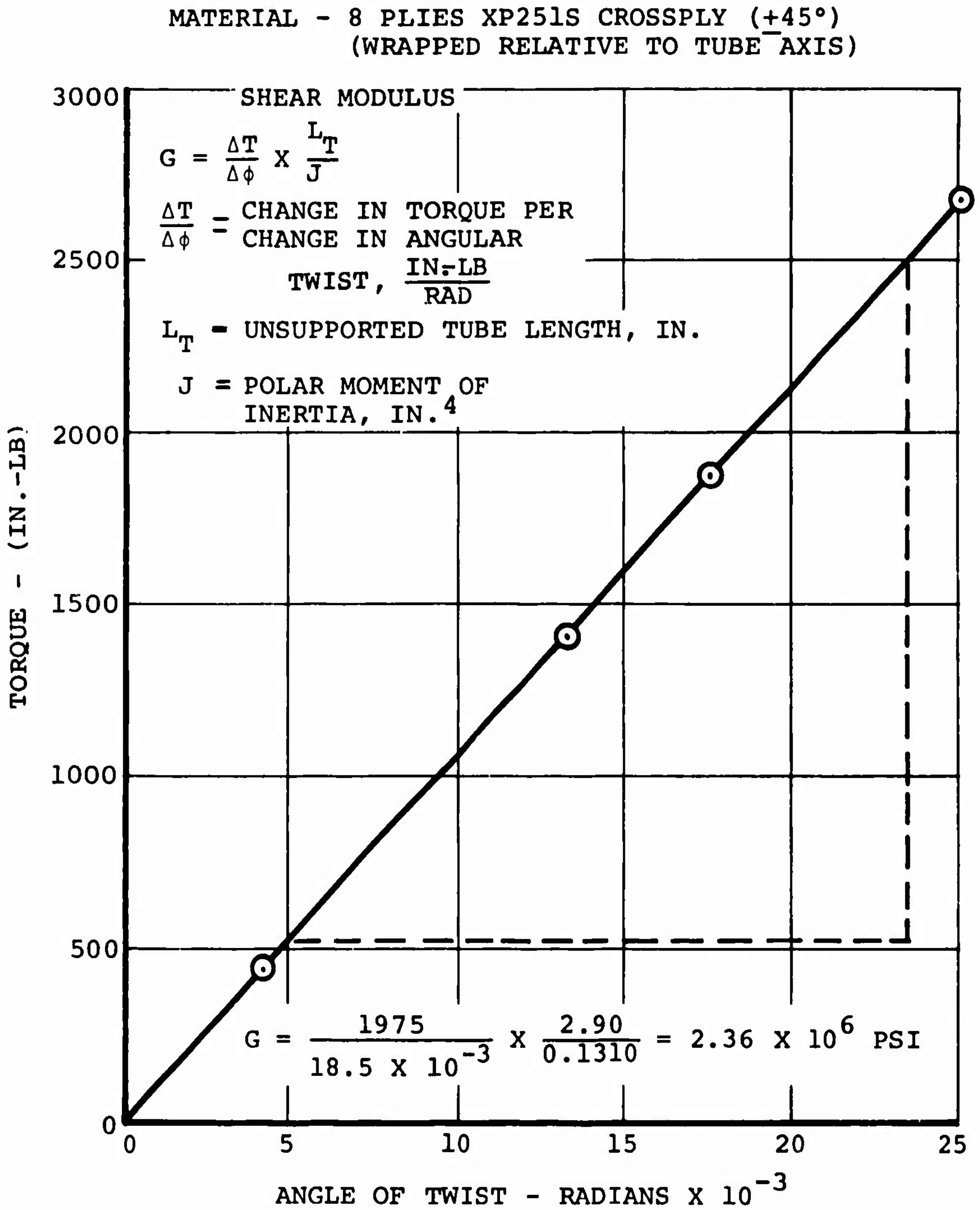


Figure 44. Calibration Curve for Determining Static Torsional Stiffness of Fiber Glass Tube Specimen TX-11-2 Tested at Room Temperature.

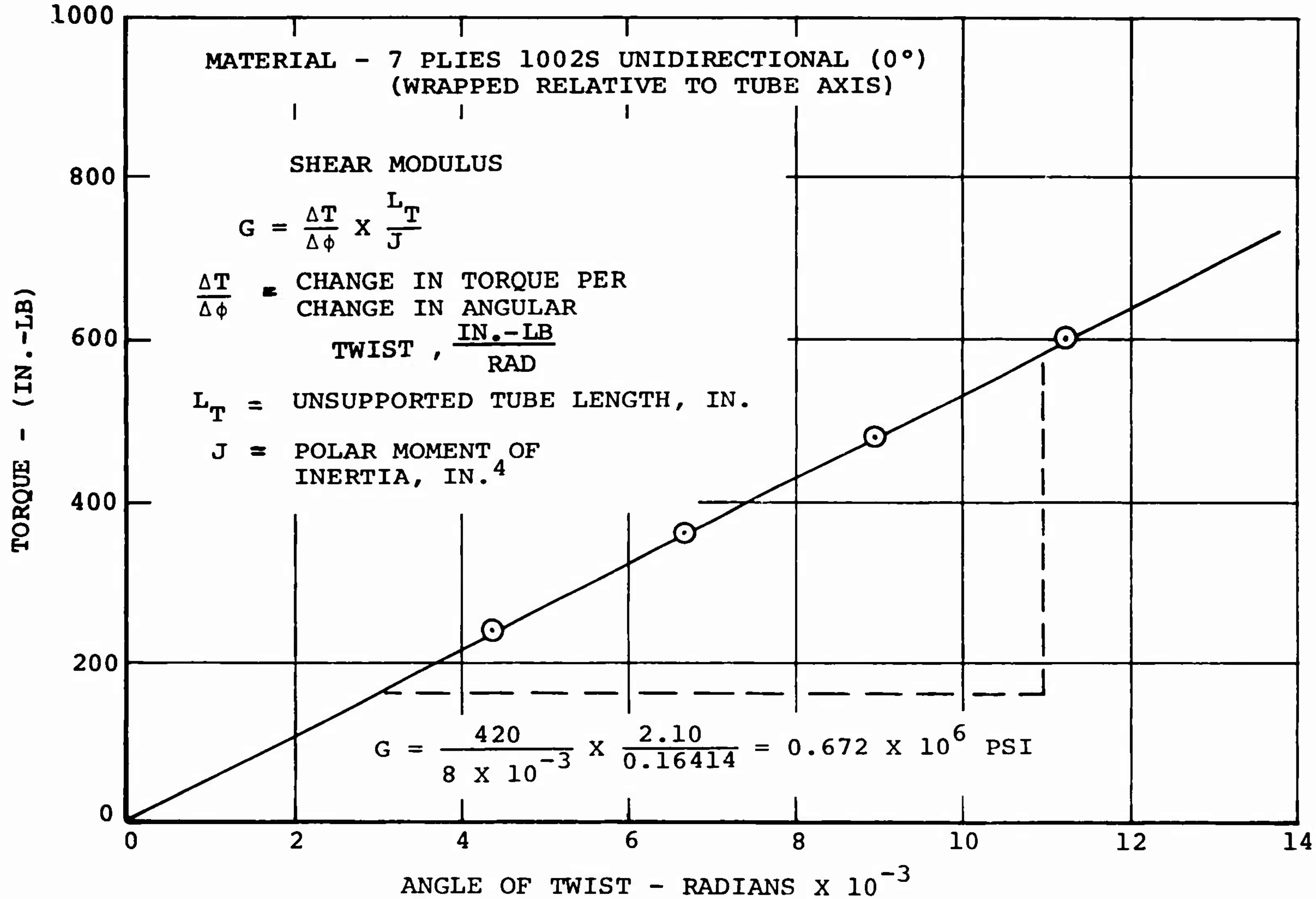


Figure 45. Calibration Curve for Determining Static Torsional Stiffness of Fiber Glass Tube Specimen Tu 24-3 Tested at Room Temperature.

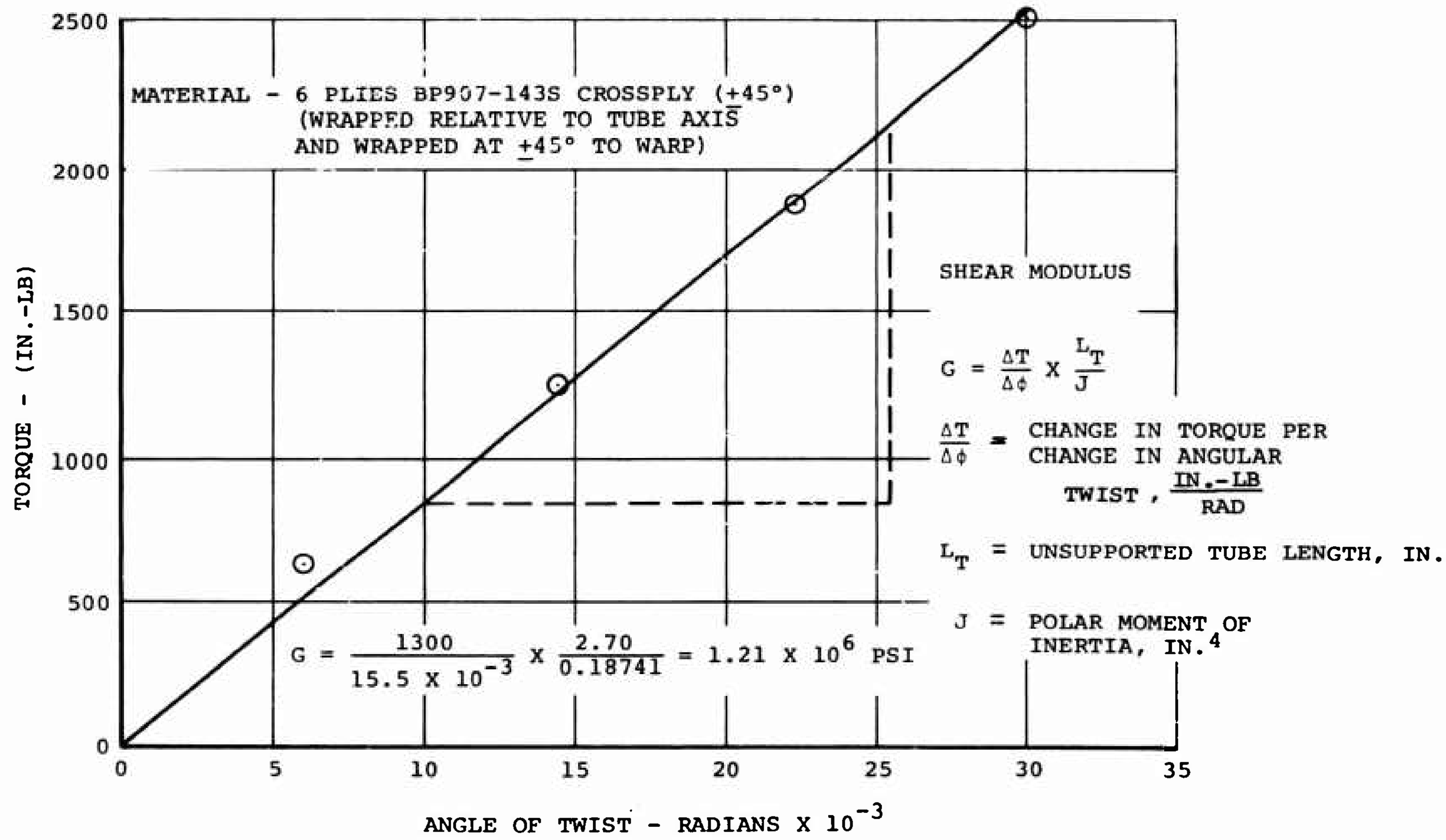


Figure 46. Calibration Curve for Determining Static Torsional Stiffness of Fiber Glass Tube Specimen TX-27-2 Tested at Room Temperature.

$$G = \frac{\Delta T}{\Delta \phi} \frac{L_T}{J}$$

where G = shear modulus, psi

$\frac{\Delta T}{\Delta \phi}$ = change in torque per change in angular twist, $\frac{\text{in.-lb}}{\text{rad}}$

L_T = unsupported tube length, in.

J = polar moment of inertia, in.^{4}

The shear strength was calculated by the following method:

$$f_s = \frac{16\ T\ D_o}{\pi (D_o{}^4 - D_i{}^4)}$$

where T = applied torque, in.-lb

D_o = outside tube diameter, in.

D_i = inside tube diameter, in.

The torsional stiffness versus wrap angle for both unidirectional and crossply fiber glass materials is shown graphically in Figure 47. The applied tube torque versus the tube shear strain is shown graphically in Figure 48. A typical S-N curve for the torsion tubes is shown in Figure 49.

Typical static fiber glass torsion tube specimen failures are shown in Figures 50 through 54. The test results are contained in Table XIII. In addition, a complete description of the testing environment, and specimen identification information are contained in Table XIII.

The BP907-143S and XP251S crossply specimens exhibited shear stiffness values at room temperatures of 1.3 x 10^6 to 2.5 x 10^6 psi respectively. The strength values of BP907 were consistent at room temperature, averaging approximately 30 x 10^3 psi, whereas the XP251S exhibited an average of 18 x 10^3 psi. At the -65°F regime, the tubes exerted a strength increase of about 2.5 times the value recorded at room temperature.

The static unidirectional tube specimens generally exhibited failure modes of matrix fracturing or fiber separation parallel to the fiber. The crossply XP251S experienced a mode of fibers failing in tension combined with matrix fractures in the ± 45 degrees planes. There was evidence of discoloration in some areas of the tube specimens, indicating a delamination between

(1) SCOTCHPLY XP251S AND 1002S NONWOVEN ORGANIC PREPREG.

(2) BP907-143S WOVEN ORGANIC PREPREG. THE 143S WOVEN MATERIAL WAS WRAPPED AT ±45° to WARP.

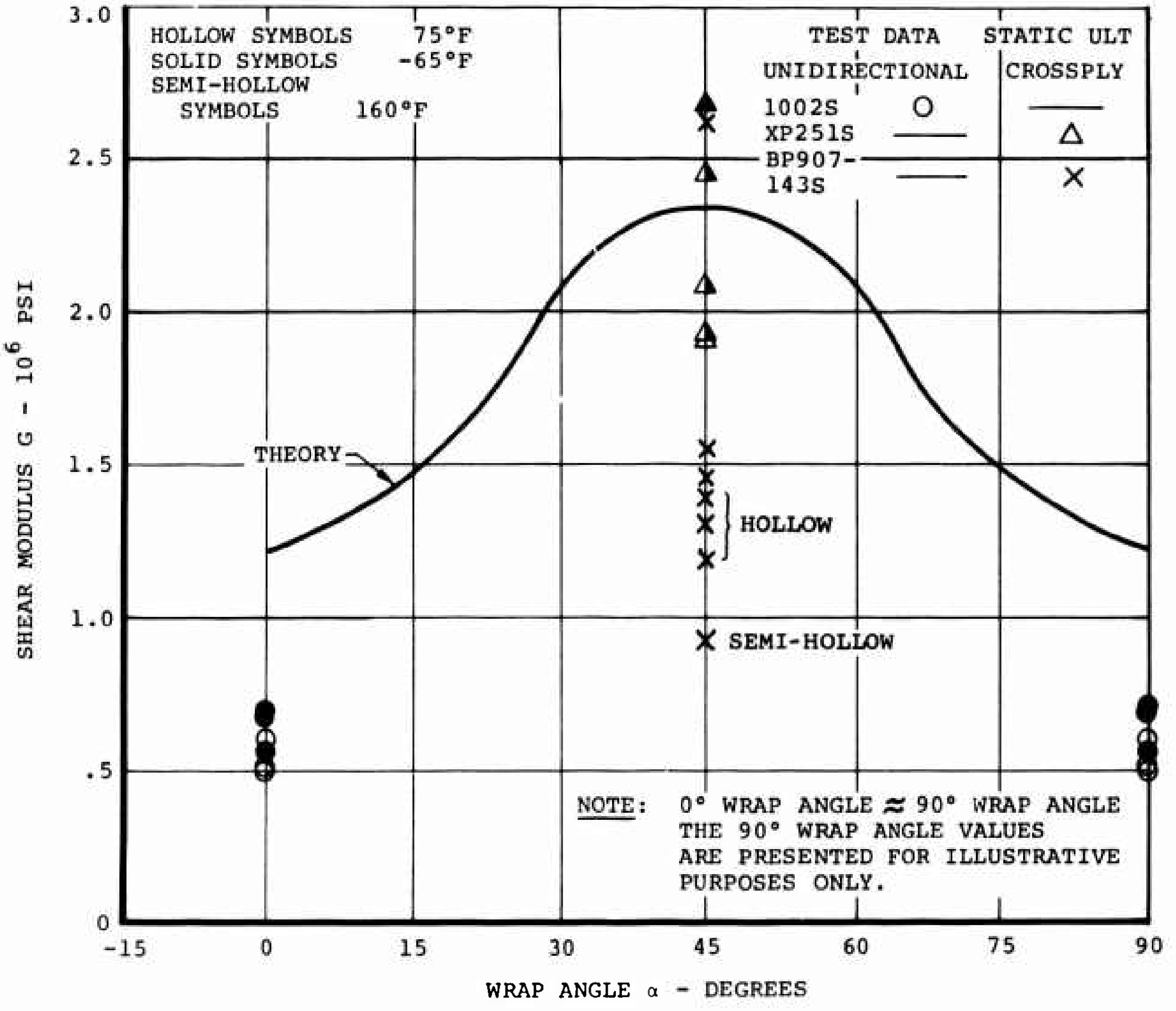


Figure 47. Torsional Stiffness Versus Wrap Angle for Epoxy Resin Tubes Reinforced With (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F, 75°F, and 160°F.

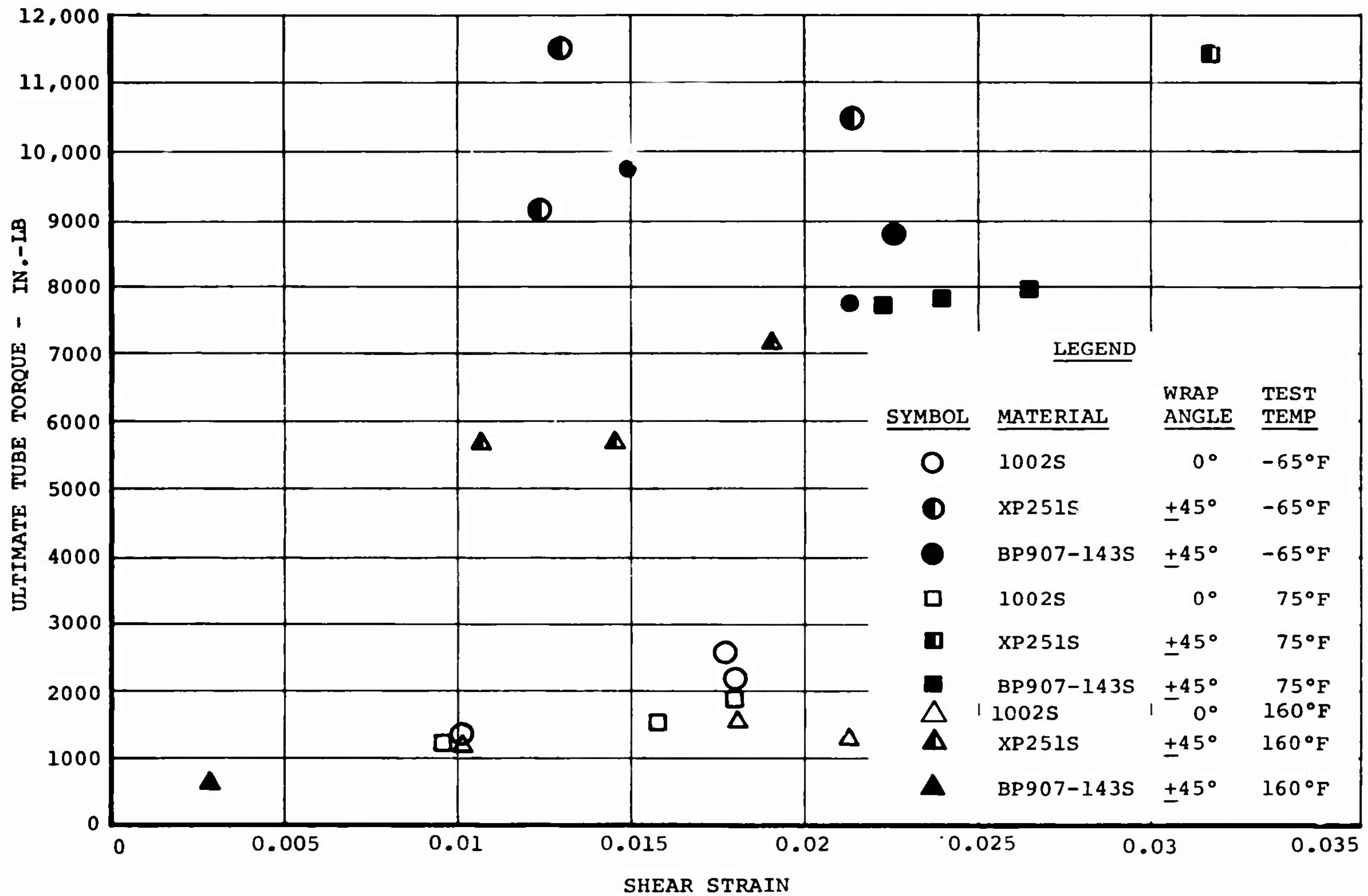


Figure 48. Ultimate Fiber Glass Tube Torque Versus Tube Shear Strain.

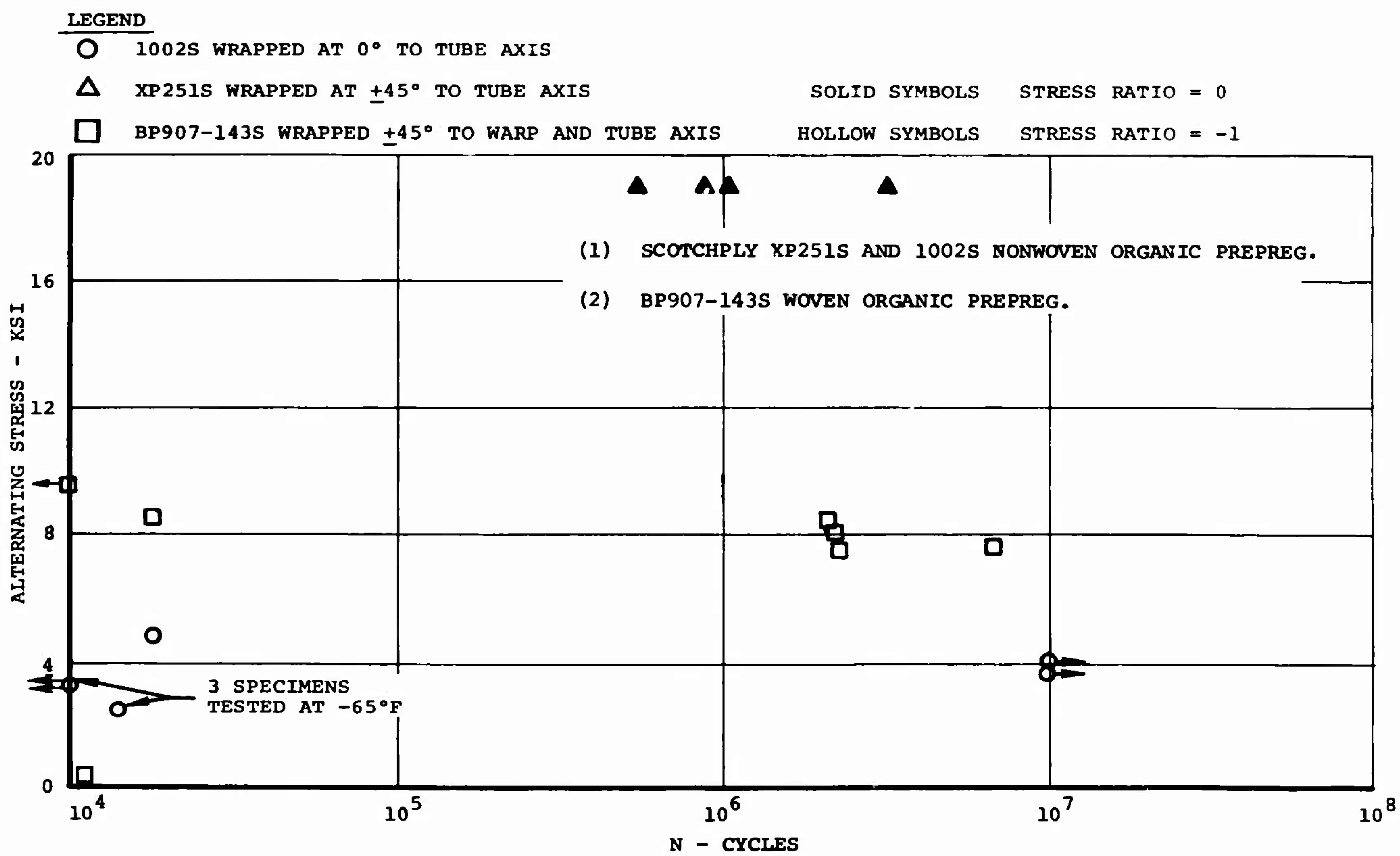
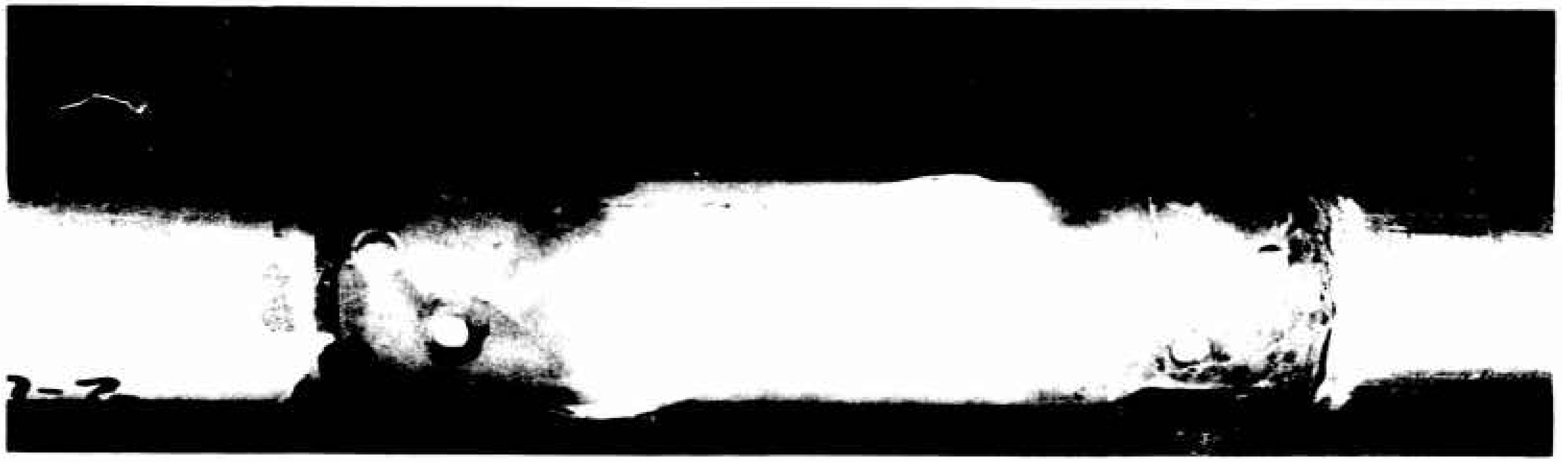


Figure 49. S-N Curve for Torsion Tubes Fabricated of Epoxy Resin Reinforced With (1) S-Glass Fibers and (2) 143 S-Style Fabric and Tested at Room Temperature or as Noted at Data Points.



MATERIAL	SCOTCHPLY XP251S (8 PLY WRAPPED AT ±45° RELATIVE TO TUBE AXIS)
TEST TEMPERATURE	-65°F
ULTIMATE TORQUE	9163 IN.-LB

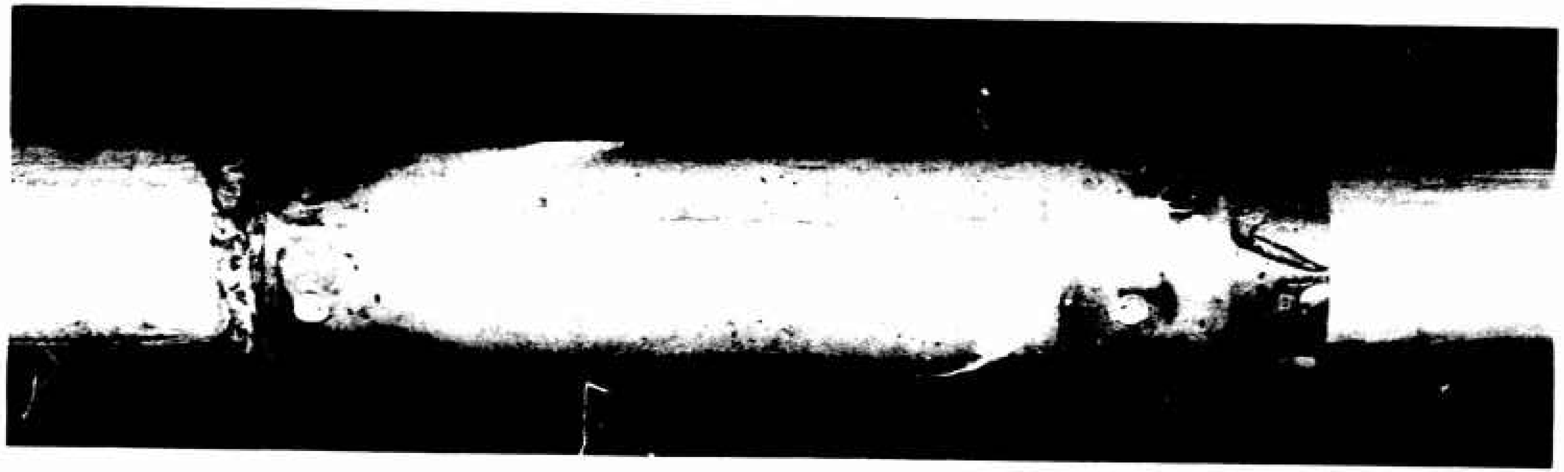
Figure 50. Static Fiber Glass Torsion Tube Failure, Specimen No. TX-7-2.

MATERIAL	SCOTCHPLY XP251S (8 PLY WRAPPED AT ±45° RELATIVE TO TUBE AXIS)
TEST TEMPERATURE	-65°F
ULTIMATE TORQUE	11,500 IN.-LB

Figure 51. Static Fiber Glass Torsion Tube Failure, Specimen No. TX-11-1.

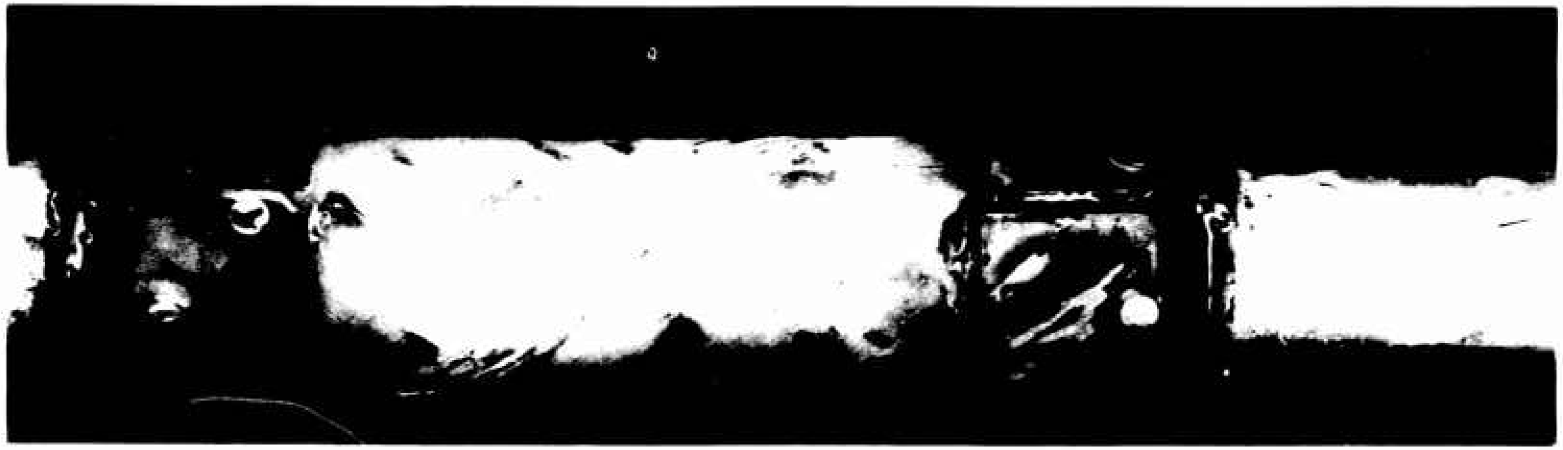
MATERIAL	BP907-143S (6 PLY WRAPPED AT ±45° TO WARP)
TEST TEMPERATURE	-65°F
ULTIMATE TORQUE	8809 IN.-LB

Figure 52. Static Fiber Glass Torsion Tube Failure, Specimen No. TX-28-2.



MATERIAL	BP907-143S (6 PLY WRAPPED AT ±45° TO WARP)
TEST TEMPERATURE	-65°F
ULTIMATE TORQUE	9750 IN.-LB

Figure 53. Static Fiber Glass Torsion Tube Failure, Specimen No. TX-25-1



MATERIAL	SCOTCHPLY XP251S (8 PLY WRAPPED AT $\pm 45°$ RELATIVE TO TUBE AXIS)
TEST TEMPERATURE	-65°F
ULTIMATE TORQUE	10,475 IN.-LB

Figure 54. Static Fiber Glass Torsion Tube Failure, Specimen No. TX-13-1.

layers. A portion of the 143S crossply specimens underwent buckling with a slight percentage of matrix and fiber failures.

There were problems during the test on the specimens, such as adhesive failure between the aluminum plugs and the specimen. Additional problems include static specimens that were susceptible to damages from the test clamps. A number of specimens experienced amplitude failures at the start of the test and ran about 2,000 to 10,000 cycles. This problem was alleviated by trial and error in lowering the loads until a satisfactory life of the specimen was accomplished. The fatigue tests were run on stress ratios of 0 and -1.0 for purposes of providing sufficient information for a statistical evaluation.

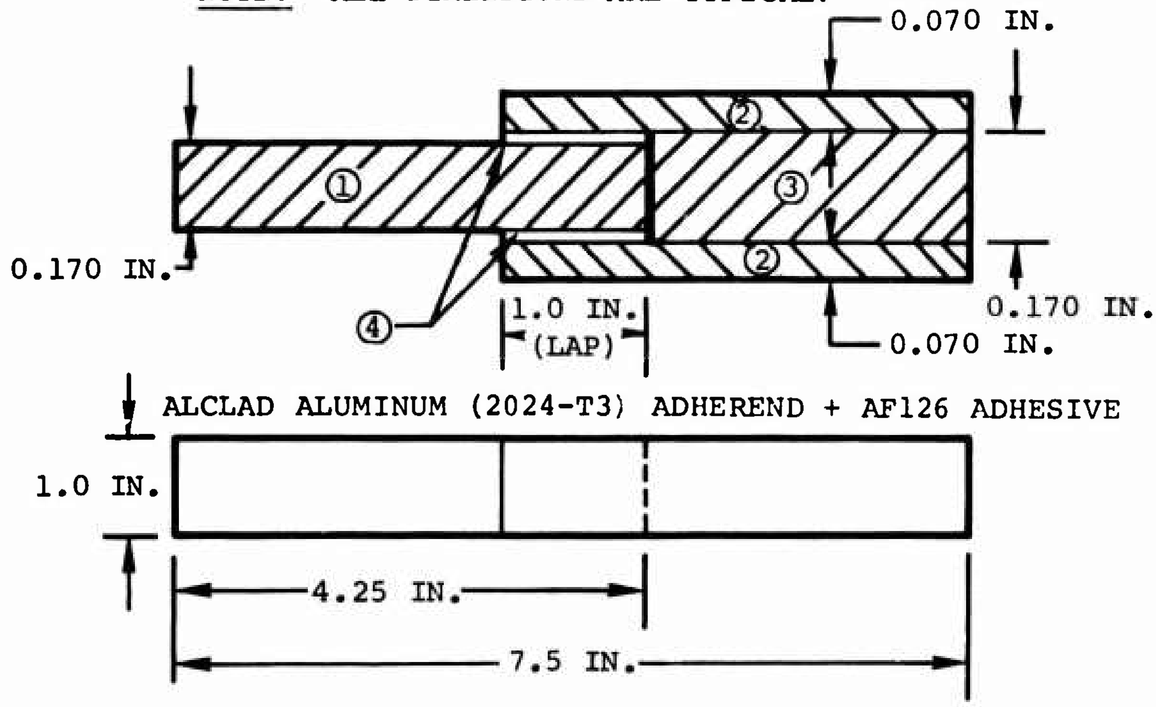
ADHESIVE BONDED JOINT TESTING

The purpose of this test was to determine the strength of three configurations of adhesively bonded double-lap joints. The joint configurations were selected on the basis of their application in the design and manufacture of fiber glass rotor blades. Other considerations were operating temperature, effects of overlap length versus adhesive joint stress, adherend material, and finally the strength degradation and joint efficiency when the specimen was exposed to various environmental conditions. Because of limitations in cost, all of the preceding factors could not be investigated. The test program was reduced to encompass 3 basic designs to bonded joint configurations. The overlap length and width of each configuration were held to 1 and 2 inches, respectively. The joints in configurations 2 and 3 (see Figures 56 and 57) are of the metal-to-fiber glass type, while those of configuration 1 (Figure 55) are of the metal-to-metal type. The adhesive used was AF-126. The static and fatigue tests were conducted at 75°F 75°F. The static tests were performed with five specimens, the fatigue tests with six. All testing was done on a Sonntag fatigue machine equipped with a 5 to 1 multiplying tension fixture and instrumented link to monitor the loading. The test results are shown in Table XIV.

Configuration 1

Configuration 1 failures were consistent in the aluminum adherend. All of the 6 specimens that were fatigue tested resulted in the absence of failures in the desired adhesive area. There is some indication that the failures were attributed to fretting occurring between the test grips and aluminum adherend. The maximum life was recorded at 1.365 x 10^6 cycles for a stress of 650 psi, whereas the lowest was 0.198 x 10^6 cycles

NOTE: ALL DIMENSIONS ARE TYPICAL.



MATERIALS

① AND ② ALCLAD ALUMINUM (2024-T3)

③ ALCLAD ALUMINUM (2024-T3 FILLER)

④ AF126 ADHESIVE

FABRICATION PROCEDURE

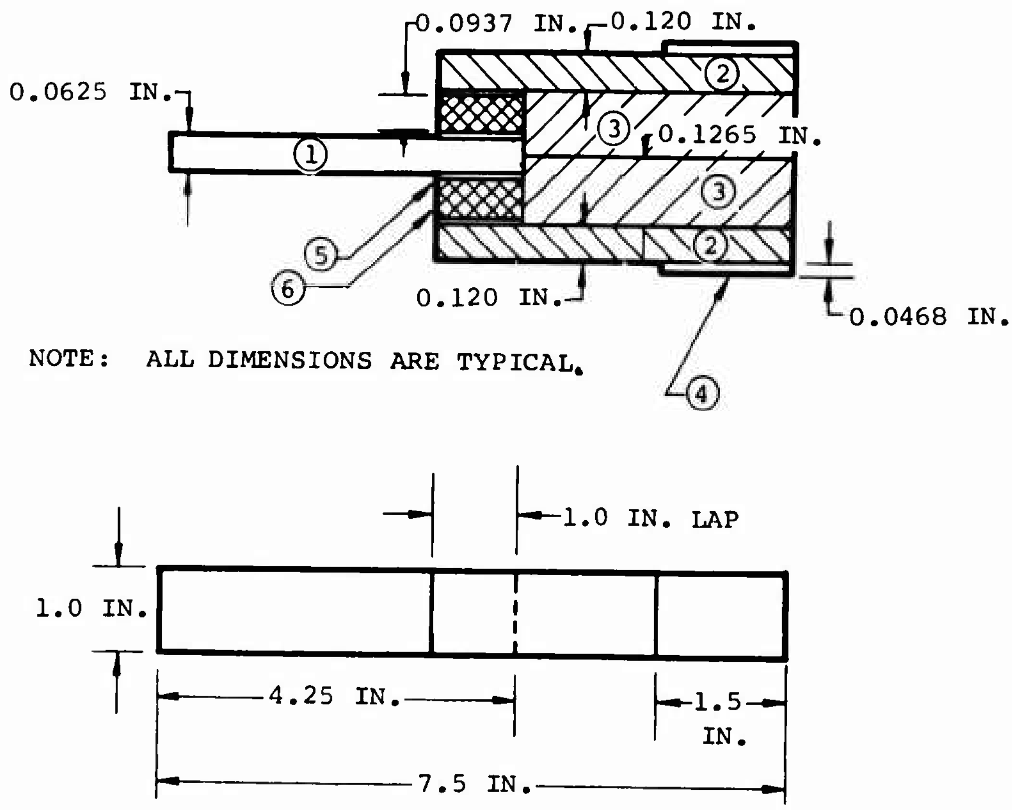
1 HOUR @ 225-250°F @ 50 PSI. HEATUP RATE @ 1.5°F/MIN. ALL SPECIMENS CURED IN AN AUTOCLAVE.

SPECIMEN QUANTITY

NO. OF SPECIMENS	TYPE OF TEST
6	FATIGUE

TEST TEMPERATURE 75°F

Figure 55. Adhesive Joint Fabrication, Configuration 1.



TITANIUM 6-4 AND XP251S GLASS ADHERENDS + AF126 ADHESIVE

1. TITANIUM (Ti-6Al-4V)
2. XP251S - UNIDIRECTIONAL (PRECURED)
3. XP251S - UNIDIRECTIONAL FILLER (PRECURED)
4. ALCLAD ALUMINUM (2024-T3) DOUBLERS
5. AF126 ADHESIVE
6. XP251S - ±45° CROSSPLY (PRECURED)

FABRICATION PROCEDURE

NOTE: AUTOCLAVE CURE IS ACCOMPLISHED AT 330-340°F, 50 PSI. HEATUP RATE IS 1.5°F PER MINUTE.

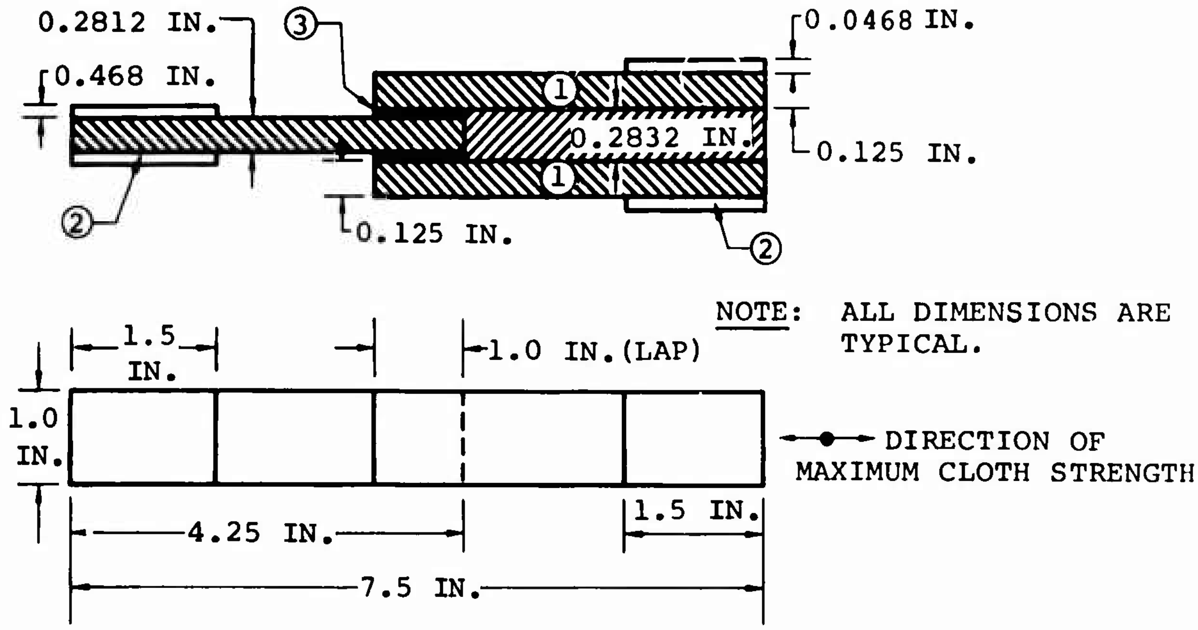
STEP 1 - PRECURE ALL XP251S GLASS SKINS FOR 1 HOUR BEFORE SPECIMEN FABRICATION.

STEP 2 - CURE COMPLETE ASSEMBLY FOR 1 HOUR.

STEP 3 - FOR CONFIGURATION 4, REPEAT THE CURE CYCLE (STEP 2) 3 TIMES.

Figure 56. Adhesive Joint Fabrication, Configurations 2 and 4.

BP907/143S GLASS ADHERENDS + AF126 ADHESIVE



MATERIALS

① BP907/143S GLASS CLOTH UNIDIRECTIONAL (PRECURED)

② ALCLAD ALUMINUM (2024-T3) DOUBLERS

③ AF126 ADHESIVE

④ BP907/143S GLASS CLOTH UNIDIRECTIONAL FILLER (PRECURED)

FABRICATION PROCEDURE

STEP 1) PRECURE: ALL BP907/143S GLASS SKINS FOR

TIME, MINUTES	TEMPERATURE, °F	PRESSURE, PSI	HEATUP RATE
30	175-180	50	1.5°F/MIN
30	280-290	|	|
60	330-340	|	|

STEP 2) CURE: COMPLETE ASSEMBLY FOR 1 HOUR @ 330-340°F @ 50 PSI. HEATUP RATE @ 1.5°F/MIN

NOTE: ALL TEMPERATURES AND PRESSURES REFER TO AUTOCLAVE CURE PROCESS.

SPECIMEN QUANTITY

NO. OF SPECIMENS	TYPE OF TEST
6	FATIGUE
5	STATIC

TEST TEMPERATURE 75°F

Figure 57. Adhesive Joint Fabrication, Configuration 3.

Configuration 2

The average bond stress for panel B was 3239 psi, whereas the average stress for panel D was 3618 psi. As a comparison, the adhesive bond strength in panel D had increased approximately 10.5 percent (see Figure 58). The data indicated that no degradation in adhesive strength would be incurred in subjecting the material to repeated cure cycles as required in multistage fabrication. Strength of the joint can vary due to factors such as the adhesive batch used, the configuration of joint, and the bond compatibility between the adherend and adhesive. Typical adhesive failures in panel D are shown in Figure 60.

The curve shown in Figure 58 represents an average bond strength between XP251S Scotchply and titanium. The various overlap lengths are a result of the deviation of measurements and were plotted as a function of bond stress.

The fatigue results for panels B and D illustrate the change in strength for two identical joint configurations. There was only one difference, however; panel D was triple cured whereas panel B received a single cure. Panel B ranged from 350 to 500 psi and had a maximum cycle life of 3.192×10^6 at 350 psi. Panel D experienced a higher stress but a shorter life. The range was 450 to 900 psi and a maximum life of 0.140×10^6 at 500 psi. A complete presentation of fatigue data is shown in Figure 59.

Configuration 3

The static average stress for panel C was 5092 psi. The stress distribution was consistent and showed little deviation. The increase in strength of panel C was quite high in comparison to panels B and D. The apparent increase may be attributed to the thicker and more elastic BP907-143S adherend. However, the cohesive compatability of the BP907 resin and the AF126 adhesive used in blade fabrication was demonstrated. Figure 61 illustrates typical static adhesive failures in panel C.

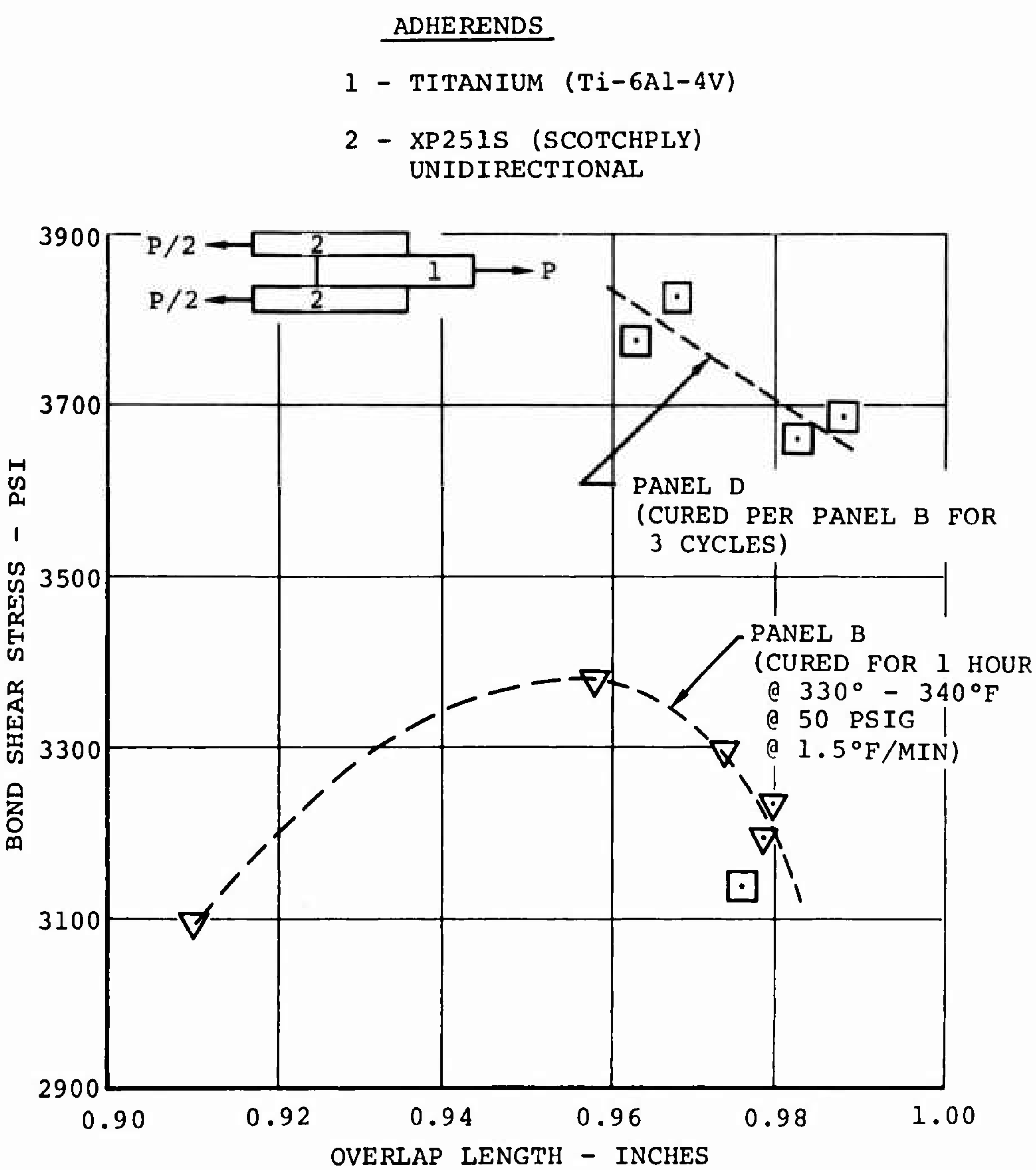


Figure 58. Stresses in Double Lap Joint Bonded With AF126 Adhesive Tested at Room Temperature.

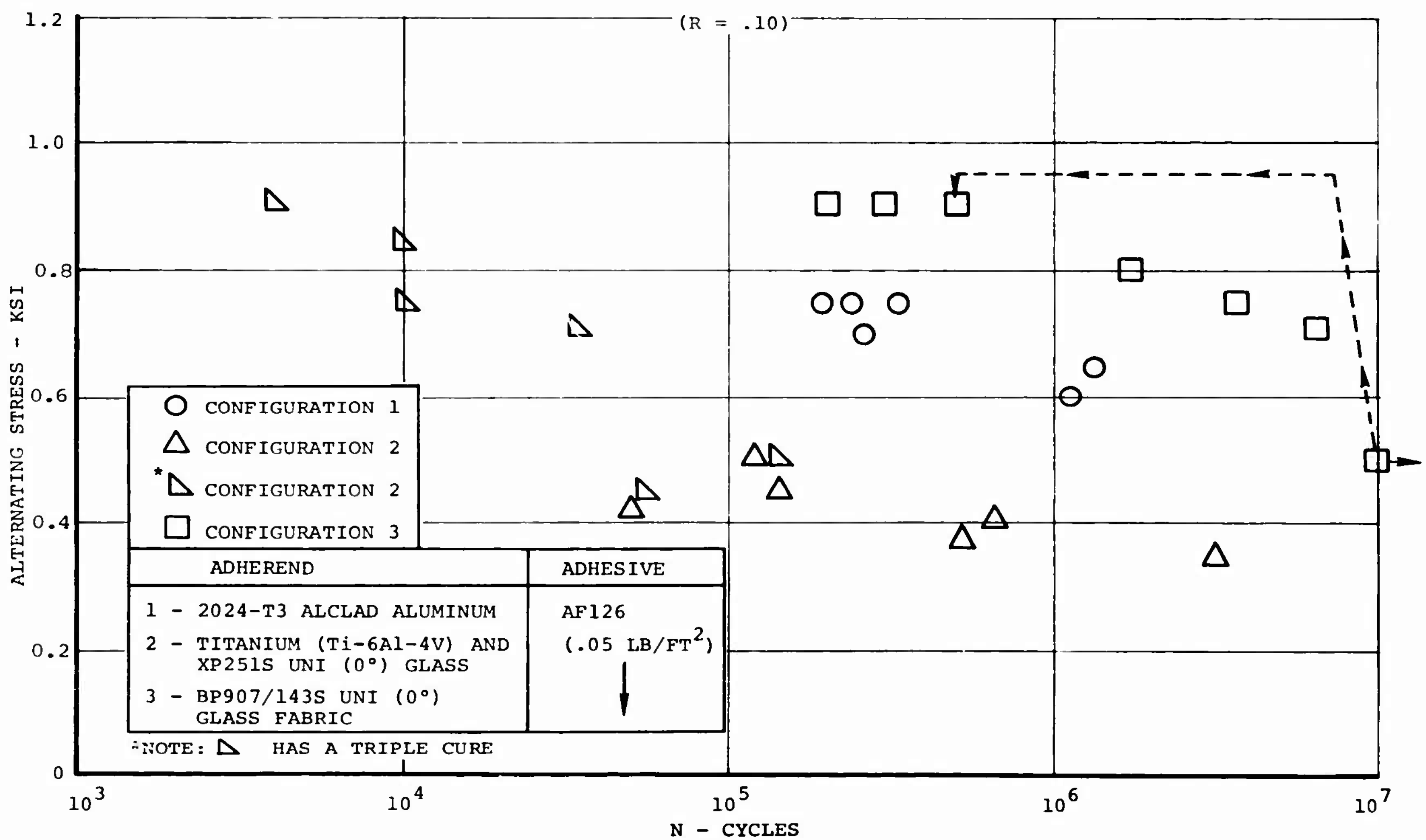
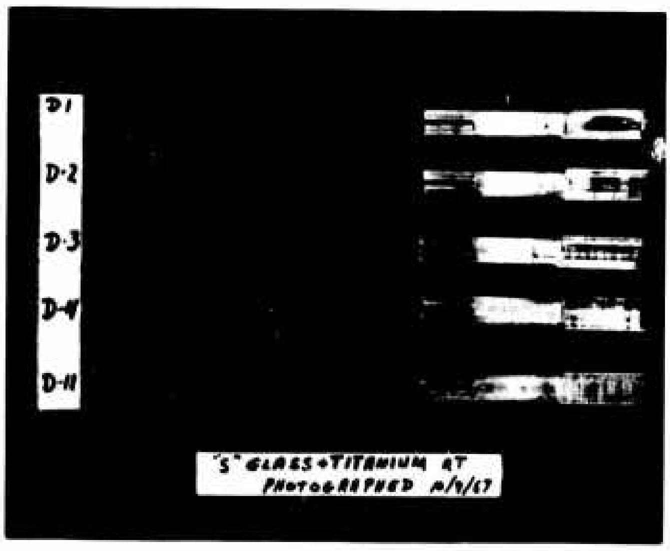


Figure 59. Fatigue Properties of Adhesive Bonded Double Lap Shear Joints Tested at Room Temperature (75°F).



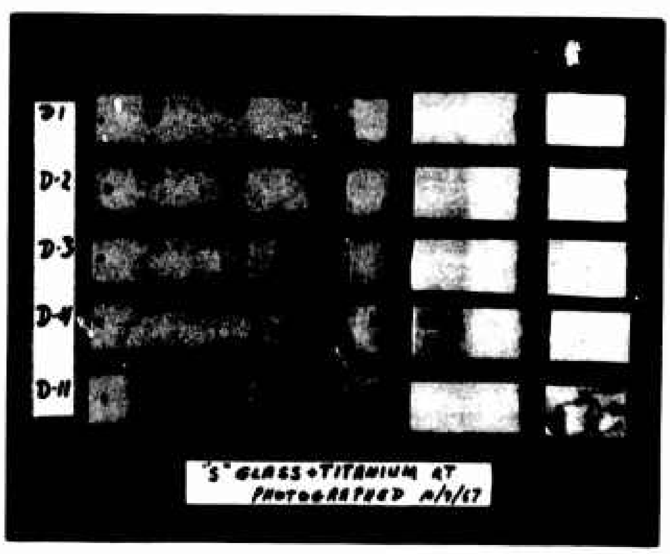
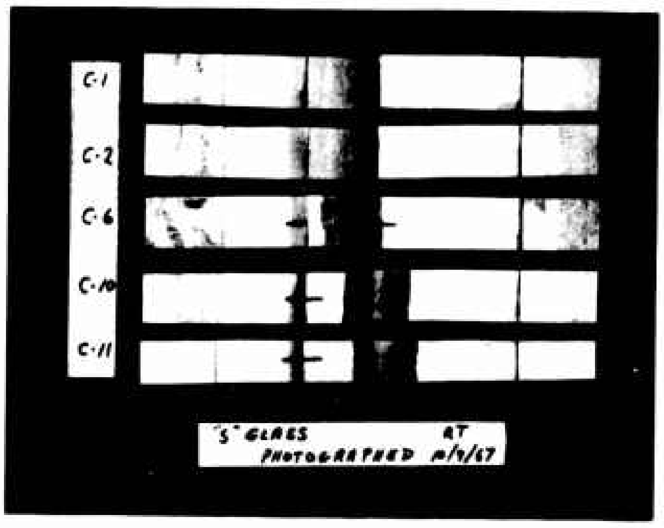


Figure 60. Double Lap Shear Specimens (Configuration 2) Tested at Room Temperature.



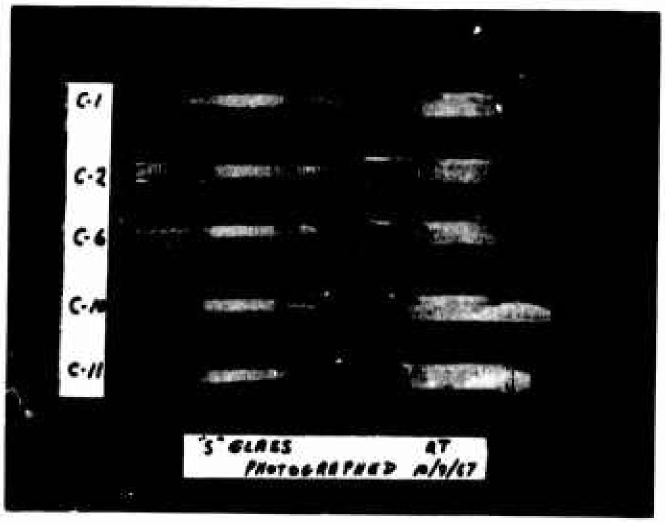


Figure 61. Double Lap Shear Specimens (Configuration 3) Tested at Room Temperature.

CONCLUSIONS

Static and dynamic properties of aluminosilicate S-glass prepreg materials were obtained over a range of processing and environmental parameters necessary for the application of these materials to airframe structures. Emphasis was placed on those specific fabrication and design factors applicable to helicopter rotor blades.

The significant conclusions derived from the program are shown below:

- The materials tested have shown adequate strength, modulus, and fatigue properties for successful utilization in aircraft load-bearing structures.

- A method for the reduction of room temperature fatigue properties is required in order to account for the effects of process availability and temperature and weathering environments.

Characteristically, simple room temperature design properties tests are conducted early in material evaluations since the more complete environmental tests are both time-consuming and expensive. A criterion for accounting adequately for environmental effects in early preliminary design data is needed.

A recommended approach using room temperature data consists of computing a best-fit line for the fatigue data or transposing the data to $N = 10^7$ cycles and evaluating the statistical characteristics. The fitted mean-line through the data is usually graphically shown along with a mean-minus-three-standard-deviation line ($\overline{X} - 3\sigma$) passed below the data. Over the range, 10^5 to 10^7 cycles, the statistical minimum line is reduced by a factor of 1.75, which is intended to account for the unknown influences of environment and size effects in the design curve. From 10^5 cycles, the reduced design curve is projected back through the tangent to the $\overline{X} - 3\sigma$ or the static allowable strength, whichever is least. This procedure is demonstrated in Figure 62 using available Boeing room temperature fatigue data for 1002S-glass unidirectional laminates tested in tension-tension fatigue. It may be seen in Figure 63 that when the applicable environmental data documented in this program are displayed in the data field, the suggested preliminary design allowable criteria are adequate to account for reductions in strength due to temperature extremes. A similar presentation has been made for XP251S crossplied material. The available Boeing data are shown in Figure 64 along with the characterizing statistical lines which were computed from the given data.

Figure 65 demonstrates the recommended criteria by displaying the environmental data obtained in this program in the S-N data field. The crossplied data exhibit the expected major reductions in fatigue strength due to high temperature. It may be seen in Figure 65 that the recommended criteria are adequate for all points above 10^5 cycles.

The mean-minus-three standard deviation reduced by a factor of 1.75 is adequate to account for temperature effects in establishing design allowables from room temperature coupon fatigue data. The data presented indicate this is to be true at least for the region $N = 10^5$ to $N = 10^7$ cycles. Unidirectional material fatigue strength is reduced in the cold temperature range, and conversely the ± 45 degree crossplied laminate fatigue strength is reduced in the high temperature range.

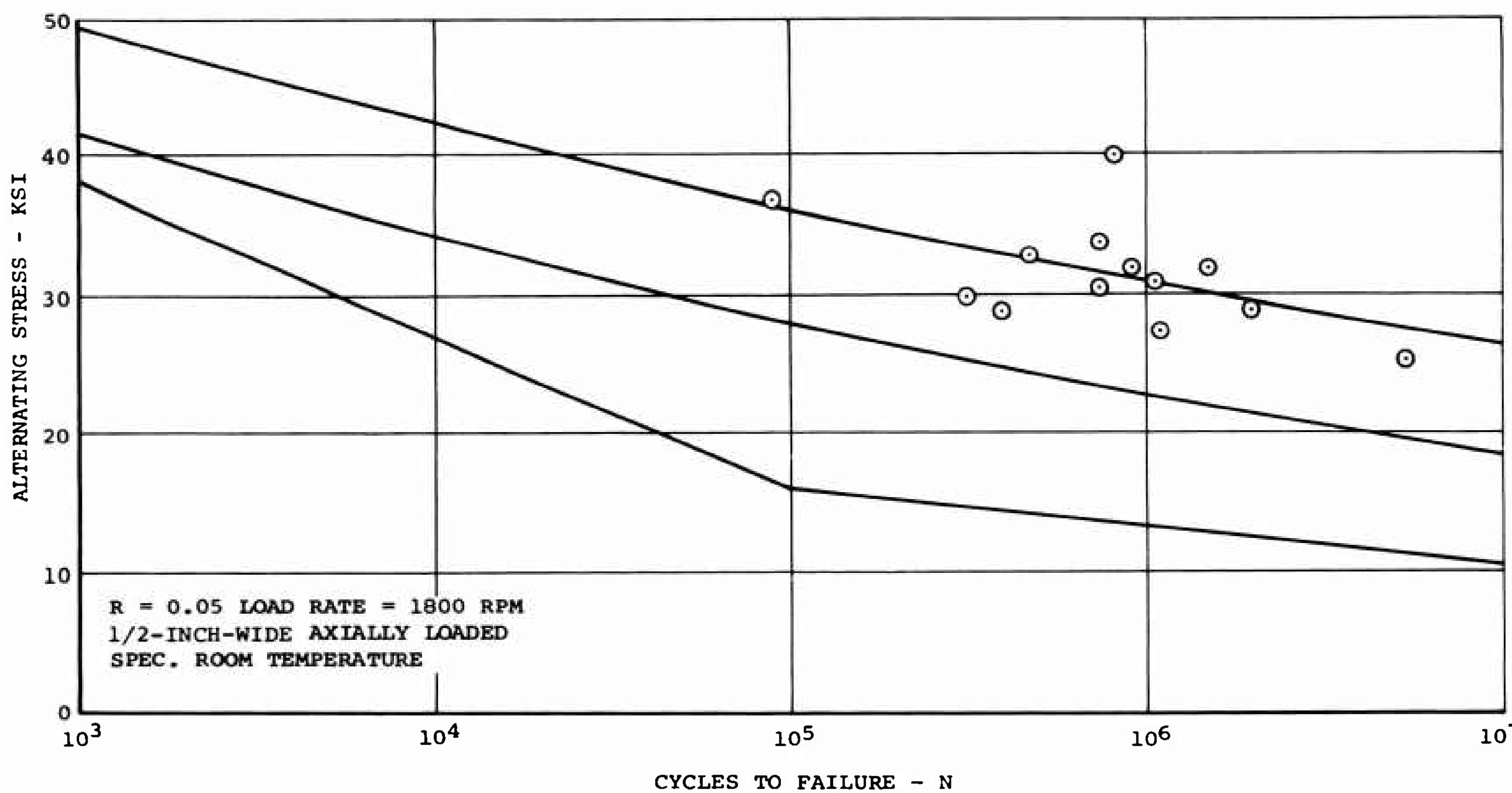


Figure 62. Laminate Fatigue Testing of Unidirectional 1002 S-Glass.

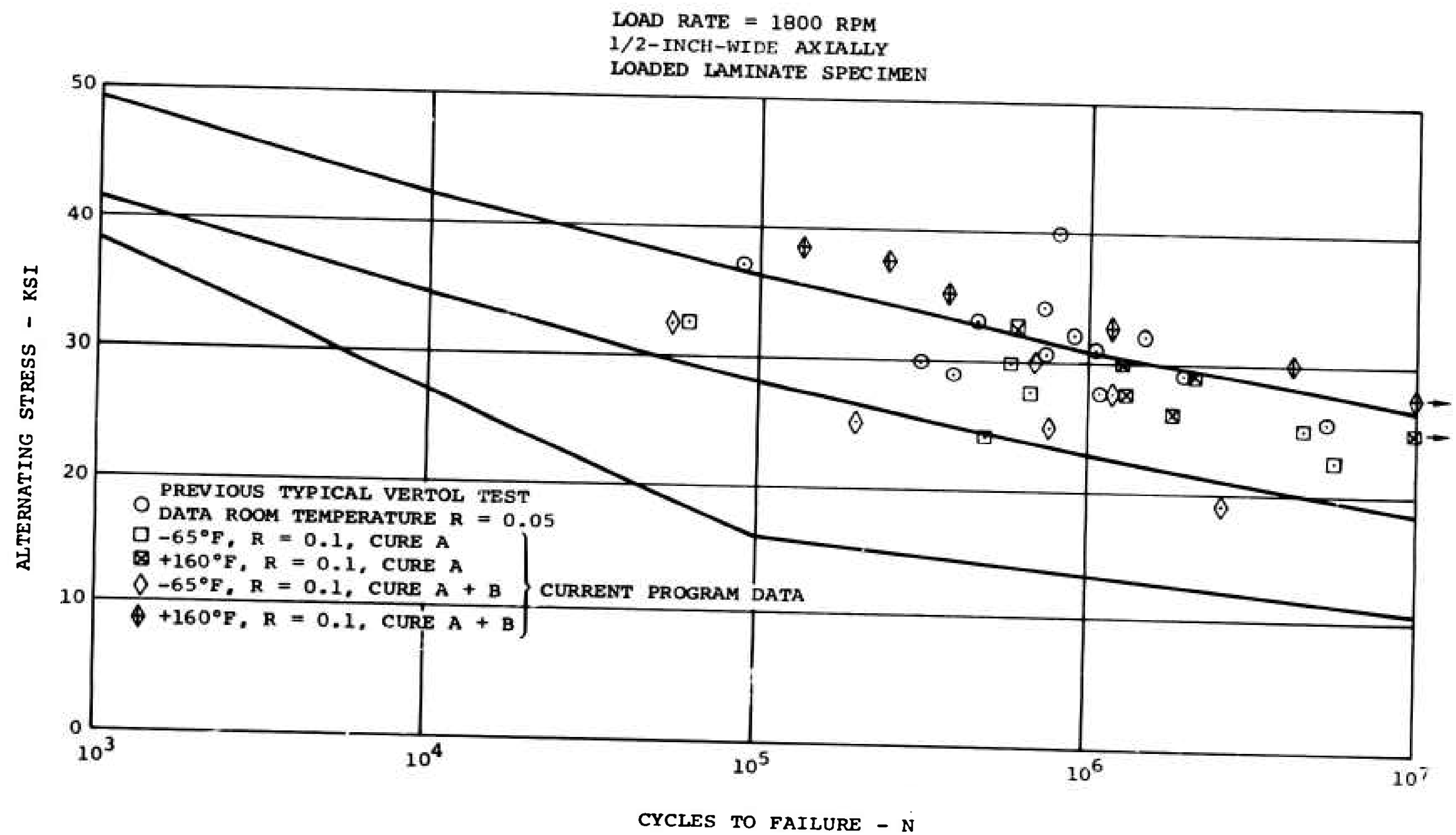


Figure 63. Fatigue Testing of Unidirectional 1002 S-Glass.

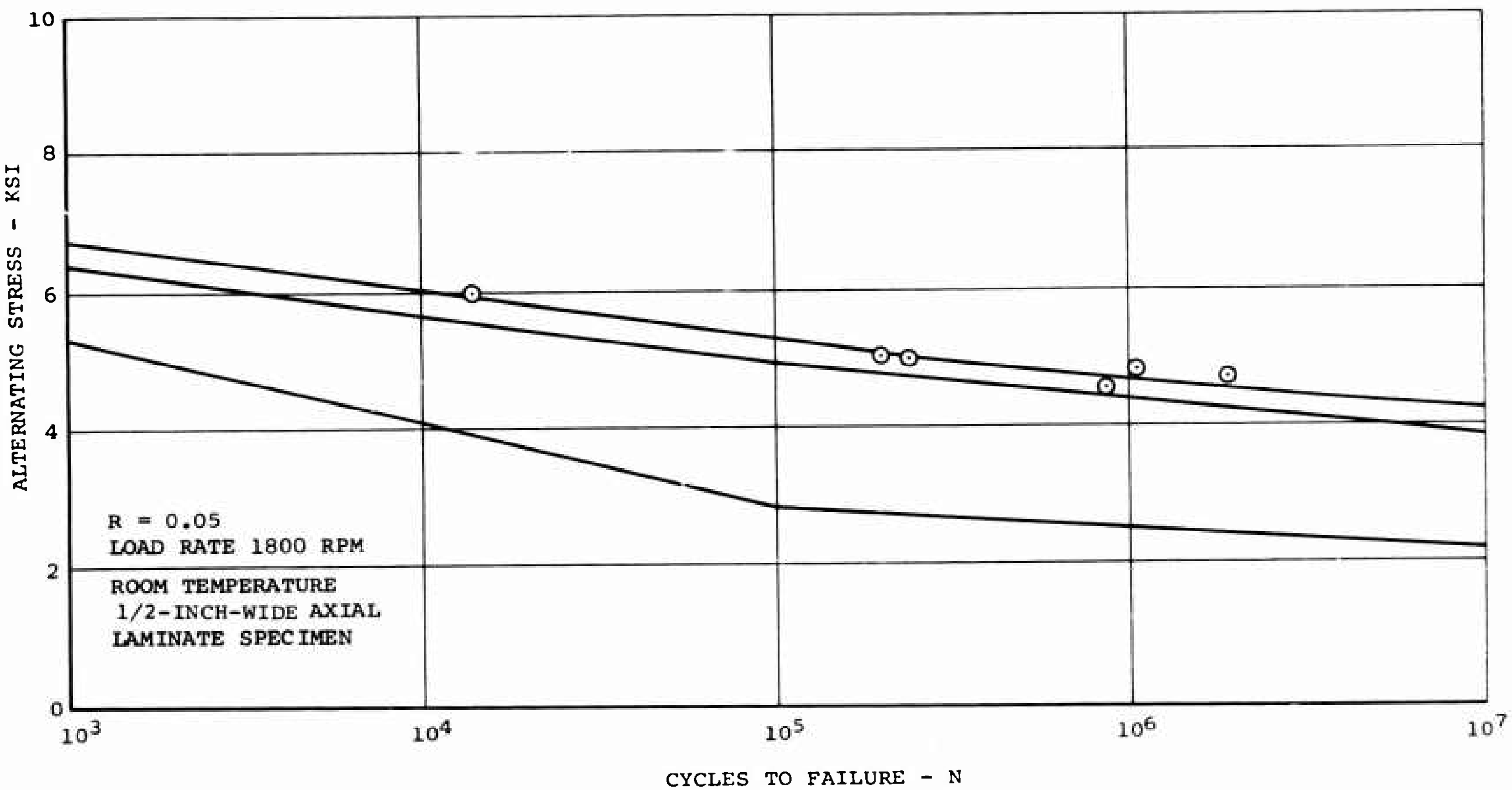


Figure 64. Fatigue Testing of ±45 Degree XP251 S-Glass.

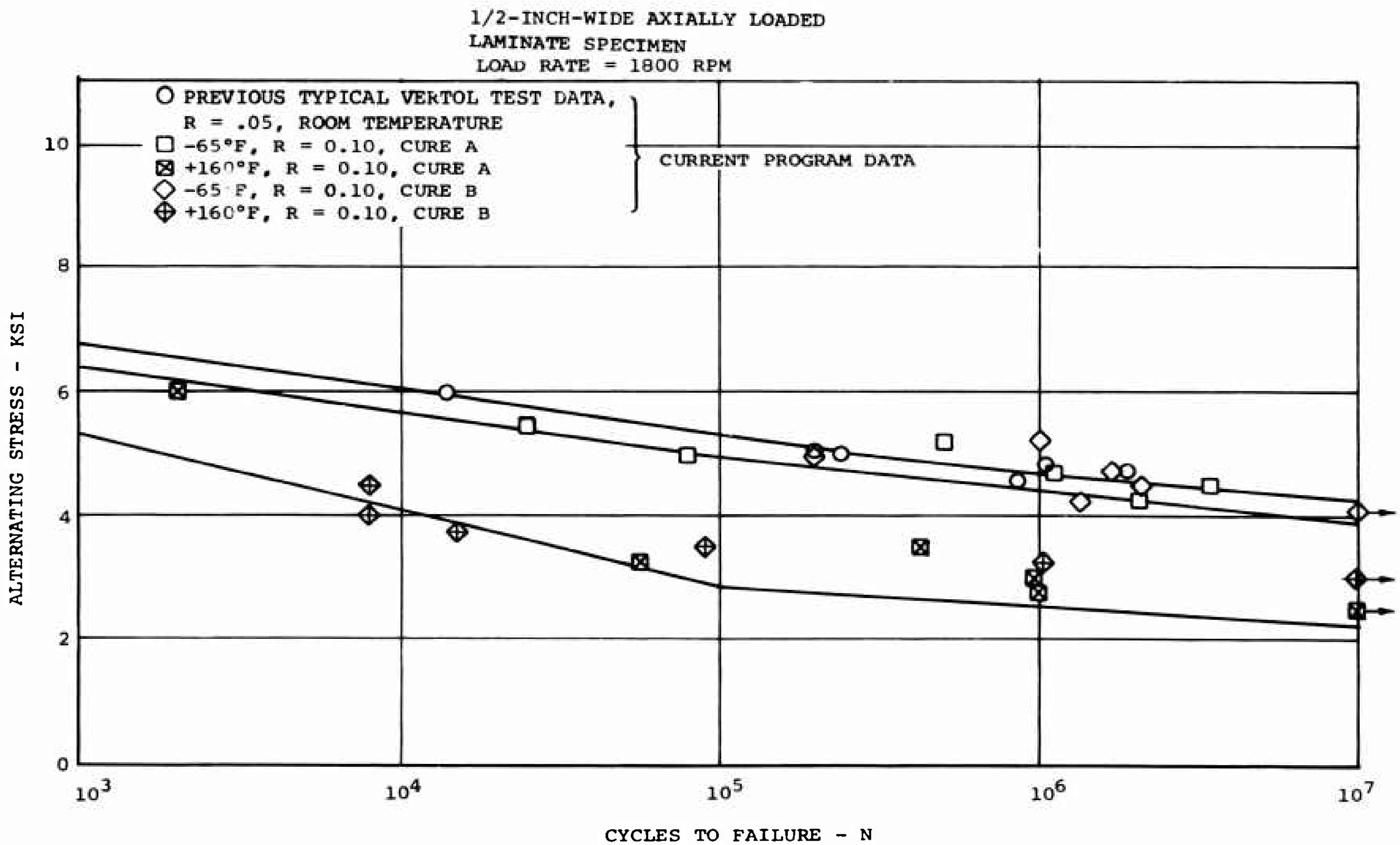
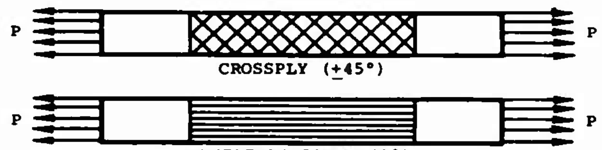


Figure 65. Fatigue Testing of ± 45 Degree XP251 S-Glass.

APPENDIX
SUMMARY OF TEST DATA

TABLE VII. TENSILE PROPERTIES FOR EPOXY RESIN LAMINATES REINFORCED WITH (1) S-GLASS FIBERS AND (2) 143-STYLE FABRIC AND TESTED AT -65°F, 75°F, AND 160°F.



Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Dimensions Width (In.)	Dimensions Thick (In.)	Dimensions Area (In.^{2})	Test Temp (°F)	Ultimate Strength Load (lb)	Ultimate Strength Stress (ksi)	Ultimate Strength Modulus (10^6psi)	Type of Failure
L-1B	27	1002S	7	0	A+B	0.523	0.059	0.031	75	8000	258.1	7.16	d,a,b
	28		7	0	A+B	0.523	0.058	0.030	75	7950	265.0	7.20	d,a,b
									Avg	7975	261.55	7.18	
L-2	1	1002S	7	0	B	0.495	0.058	0.029	75	7200	284.3	7.03	a,b,d
	2		7	0	B	0.517	0.058	0.030	75	7400	246.7	7.67	a,d,b
	3		7	0	B	0.484	0.057	0.028	75	6550	233.9	8.07	a,d,b
									Avg	7050	255.0	7.59	
L-2B	2	1002S	7	0	B	0.499	0.060	0.030	75	4925	164.2	6.54	d,c,b,a
	3		7	0	B	0.498	0.060	0.030	75	7750	258.3	6.87	d,a,b
	6		7	0	B	0.496	0.059	0.029	75	5050	174.1	6.90	d,c,b,a
	14		7	0	B	0.521	0.059	0.031	75	6700	216.1	6.45	d,c,b,a
									Avg	6106	203.2	6.69	
L-3	3	1002S	6	±45	A	0.495	0.048	0.024	75	572	24.1	2.12	e,b
	5	1002S	6	±45	A	0.470	0.049	0.023	75	555	24.1	2.37	e,b
	7		6	±45	A	0.469	0.050	0.024	75	560	23.9	2.07	e,b
									Avg	562.3	24.03	2.19	

(1) Scotchply XP251S and 1002S nonwoven organic prepreg

(2) BP907-143S woven organic prepreg

(3) Orientation of fibers relative to longitudinal load axis.

Cure

A. 1 hour at 330-340°F at 50 psi (Vented), plus 1 hour at 280°-290°F

B. Cure A + 16 hours postcure at 280°-290°F (Vacuum)

Failure Type

a. Interlaminar shear of layers
b. Small percentage of fiber breaks
c. Debonding of adhesive at doublers
d. Matrix fracture (parallel to fibers)
e. Matrix fracture at 45° plane
f. Complete break
g. No matrix fracture

TABLE VII. CONTINUED

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Dimensions Width (In.)	Dimensions Thick (In.)	Dimensions Area (In.^{2})	Test Temp (°F)	Ultimate Strength Load (lb)	Ultimate Strength Stress (ksi)	Ultimate Strength Modulus (10^6 psi)	Type of Failure
L-4	3		6	+45	B	0.525	0.052	0.027	75	600	22.2	1.78	—
	13		6	$\mp$45	B	0.481	0.057	0.027	75	600	22.2	1.93	—
	21		6	$\mp$45	B	0.495	0.057	0.028	75	735	26.1	1.92	e,b
	22	1002S	6	$\mp$45	B	0.485	0.057	0.028	75	720	26.1	2.01	e,b
	25		6	$\mp$45	B	0.503	0.055	0.028	75	715	25.8	2.18	e,b
	29		6	$\pm$45	B	0.466	0.052	0.024	75	530	22.1	1.75	e.b
									Avg	650	24.08	1.93	
L-25B	8	XP251S	7	0	A+B	0.526	0.053	0.028	75	4150	148.2	7.93	c,a,g,b
	9		7	0	A+B	0.524	0.053	0.028	75	4050	144.6	9.07	c,a,g,b
									Avg	4100	146.4	8.50	
L-5B	1		7	0	A+B	0.502	0.052	0.026	75	5850	225.0	8.00	a,g,b
	4	XP251S	7	0	A+B	0.521	0.052	0.027	75	7100	262.9	8.00	d,a,b
	8		7	0	A+B	0.523	0.052	0.027	75	7050	261.1	7.41	d,a,b
	14		7	0	A+B	0.521	0.052	0.027	75	6450	238.9	7.26	d,a,b
									Avg	6613	247.0	7.67	
L-25	1		7	0	A+B	0.481	0.051	0.025	75	5050	202.0	8.48	—
	2	XP251S	7	0	A+B	0.477	0.048	0.023	75	4750	206.5	8.77	—
	17		7	0	A+B	0.501	0.052	0.026	75	5700	219.2	8.07	c,a,g,b
									Avg	5167	209.2	8.44	
L-6B	1		7	0	B	0.474	0.052	0.025	75	3925	157.0	8.24	c,a,d
	2	XP251S	7	0	B	0.513	0.051	0.026	75	3100	119.2	8.46	c,a,d
	3		7	0	B	0.521	0.051	0.027	75	4175	154.6	8.30	c,a,d
									Avg	3733	143.6	8.33	
L-7	4		6	+45	A	0.516	0.044	0.023	75	583	25.7	2.45	e,b
	6	XP251S	6	$\mp$45	A	0.516	0.045	0.023	75	595	25.7	2.62	e,b
	10		6	$\pm$45	A	0.515	0.045	0.023	75	602	25.9	2.58	e,b
									Avg	593	25.76	2.55	

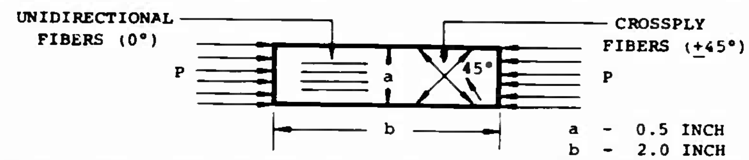
TABLE VII. CONTINUED

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Dimensions Width (In.)	Thick (In.)	Area ($In.^2$)	Test Temp (°F)	Ultimate Strength Load (lb)	Stress (ksi)	Modulus (10^6 psi)	Type of Failure
L-8	1	XP251S	6	±45	B	0.527	0.044	0.023	75	600	26.1	2.87	e,b
	5		6	±45	B	0.520	0.045	0.023	75	595	25.4	2.92	e,b
	10		6	±45	B	0.523	0.045	0.023	75	610	25.9	3.25	e,b
	15		6	±45	B	0.523	0.046	0.024	75	610	25.4	2.25	e,b
	25		6	±45	B	0.517	0.046	0.024	75	580	24.1	2.25	—
	30		6	±45	B	0.516	0.044	0.023	75	590	26.0	2.90	e,b
									Avg	598	25.48	2.74	
L-9	1	BP907 143S	7	0	B	0.486	0.076	0.037	75	6100	164.9	5.31	f,g
	2		7	0	B	0.486	0.074	0.036	75	5800	161.1	5.28	f,g
	3		7	0	B	0.516	0.076	0.039	75	6650	170.5	5.34	f,g
									Avg	6183	165.5	5.31	
L-9B	10	BP907 143S	7	0	A+B	0.518	0.079	0.041	75	6225	151.8	4.54	f,g
	11		7	0	A+B	0.518	0.080	0.041	75	5000	121.9	4.39	f,g
	12		7	0	A+B	0.519	0.082	0.043	75	6250	145.3	4.56	f,g
									Avg	5958	139.7	4.50	
L-10B	4	BP907 143S	7	0	B	0.480	0.082	0.039	75	4525	116.0	4.36	f,g
	6		7	0	B	0.491	0.081	0.040	75	5000	125.0	4.45	f,g
	12		7	0	B	0.474	0.079	0.037	75	4550	123.0	4.60	f,g
									Avg	4692	121.3	4.47	
L-2B	4	1002S	7	0	B	0.500	0.059	0.030	160	5675	189.2	6.40	c,a,b
	8		7	0	B	0.495	0.059	0.029	160	4400	151.7	6.76	c,a,b
	12		7	0	B	0.518	0.059	0.031	160	5900	190.3	6.45	a,c,b,d
									Avg	5325	177.06	6.54	
L-4	17	1002S	6	±45	B	0.523	0.057	0.030	160	690	23.2	1.41	e,b
	19		6	±45	B	0.487	0.057	0.028	160	580	20.9	1.34	e,b
	23		6	±45	B	0.526	0.057	0.030	160	620	20.7	1.31	e,b
									Avg	630	21.6	1.35	
L-5B	9	XP251S	7	0	A+B	0.518	0.052	0.027	160	6400	237.0	8.08	a,c,b,d
	11		7	0	A+B	0.523	0.052	0.027	160	6600	244.4	7.85	d,a,b
	13		7	0	A+B	0.521	0.053	0.028	160	6000	214.3	7.14	a,c,b,d
									Avg	6333	231.9	7.69	

TABLE VII. CONTINUED

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Dimensions Width (In.)	Thick (In.)	Area (In.^{2})	Test Temp (°F)	Ultimate Strength Load (lb)	Stress (ksi)	Modulus (10^6psi)	Type of Failure
L-8	11		6	±45	B	0.525	0.046	0.024	160	595	24.7	1.46	—
	23	XP251S	6	±45	B	0.516	0.046	0.024	160	550	23.2	1.62	—
	27		6	±45	B	0.519	0.045	0.023	160	560	24.0	1.85	—
									Avg	568	23.96	1.64	
L-10B	3	BP907	7	0	B	0.531	0.082	0.044	160	4760	108.2	3.64	f,g
	5	143S	7	0	B	0.479	0.082	0.039	160	4625	118.6	3.90	f,g
	7		7	0	B	0.474	0.080	0.038	160	4500	118.4	3.89	f,g
									Avg	4628	115.06	3.81	
L-2B	7		7	0	B	0.495	0.058	0.029	-65	2600	89.7	—	—
	11	1002S	7	0	B	0.513	0.058	0.030	-65	2100	70.0	—	—
	15		7	0	B	0.517	0.059	0.031	-65	2275	73.4	—	—
									Avg	2375	77.7	—	
L-4	1		6	±45	B	0.511	0.051	0.026	-65	820	31.9	—	e,b
	5	1002S	6	±45	B	0.480	0.053	0.025	-65	810	32.4	—	—
	9		6	±45	B	0.522	0.056	0.029	-65	870	30.0	—	—
									Avg	833	31.43	—	
L-5B	10		7	0	A+B	0.522	0.052	0.027	-65	1625	60.2	—	—
	12	XP251S	7	0	A+B	0.521	0.050	0.026	-65	1675	64.4	—	—
	18		7	0	A+B	0.517	0.057	0.029	-65	1625	62.5	—	—
									Avg	1642	62.36	—	
L-8	3		6	±45	B	0.517	0.045	0.023	-65	640	27.8	—	e,b
	9	XP251S	6	±45	B	0.515	0.046	0.023	-65	640	26.7	—	e,b
	25		6	±45	B	0.521	0.046	0.024	-65	640	26.7	—	—
									Avg	640	27.06	—	
L-10B	9	BP907	7	0	B	0.496	0.080	0.040	-65	3100	77.5	—	a,c
	11	143S	7	0	B	0.469	0.079	0.037	-65	2950	79.7	—	c
	13		7	0	B	0.476	0.079	0.038	-65	3000	78.9	—	c
									Avg	3017	78.7	—	

TABLE VIII COMPRESSION PROPERTIES FOR EPOXY RESIN LAMINATES REINFORCED WITH (1) S-GLASS FIBERS AND (2) 143-STYLE FABRIC AND TESTED AT -65°F, 75°F, AND 160°F.



						Dimensions				Ultimate Strength					
Panel Number	Specimen Number	Panel Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Width (In.)	Thick. (In.)	Area (In.^{2})	Test Temp (°F)	Load (lb)	Stress (ksi)	Average Stress (ksi)	Modulus (10^6psi)	Average Modulus (10^6psi)	Type of Failure
L-15A	1	BP907/	12	0	A	0.495	0.125	0.0619	75	5650	91.28		3.50		g
	2	143S	12	0	A	0.495	0.113	0.0559	75	5200	93.02	90.53	2.20	3.09	a,e
	3		12	0	A	0.489	0.116	0.0567	75	4950	87.30		3.56		a,e
L-15B	1		12	0	A+B	0.499	0.114	0.0569	75	5300	93.15		3.07		c,e
	2		12	0	A+B	0.499	0.125	0.0624	75	5500	88.14	83.74	4.50	3.65	f
	3		12	0	A+B	0.488	0.126	0.0615	75	4300	69.92		3.39		f
	1		12	0	A+B	0.500	0.124	0.0620	160	3400	54.84		3.46		g
	2		12	0	A+B	0.500	0.123	0.0620	160	3800	61.29	58.92	3.46	3.46	g
	3	BP907/	12	0	A+B	0.507	0.129	0.0650	160	3940	60.62		—		b,e
	1	143S	12	0	A+B	0.502	0.115	0.0580	-65	5650	97.41		2.507		f
	2		12	0	A+B	0.503	0.115	0.0580	-65	5100	87.93	100.86	2.723	2.73	f
	3		12	0	A+B	0.500	0.116	0.0580	-65	6800	117.24		2.973		f
	1		12	0	A+B	0.519	0.131	0.0700	75**	4550	65.0		2.787		f
	2		12	0	A+B	0.498	0.125	0.0620	75**	4225	68.15	66.20	6.540	3.86	f
	3		12	0	A+B	0.519	0.131	0.0680	75**	4450	65.44		2.246		f
L-14A	1		16	±45	A	0.496	0.105	0.0521	75	1500	28.79		2.34		d
	2	XP251S	16	±45	A	0.484	0.110	0.0532	75	1510	28.38	28.98	2.81	4.19	d
	3		16	±45	A	0.490	0.109	0.0534	75	1590	29.79		7.42		d

(1) Scotchply XP251S and 1002S nonwoven organic prepreg
(2) BP907-143S woven organic prepreg

(3) Orientation of fibers relative to longitudinal load axis

Cure

A - 1 hour at 280-290°F + 1 hour at 330-340°F at 50 psig, vented

B - Cure A + 16 hours postcure at 280-290°F, under vacuum pressure

** Conditioned 30 days at 120°F condensing humidity and tested within 30 minutes after removal from humidity cabinet at 75°F

Failure Type

a. Edgewise shear perpendicular to load axis
b. Double edgewise shear perpendicular to load axis
c. Edgewise shear at 45° plane to load axis
d. Matrix fracture parallel to fiber direction
e. Partial specimen separation
f. Complete specimen separation
g. No failure

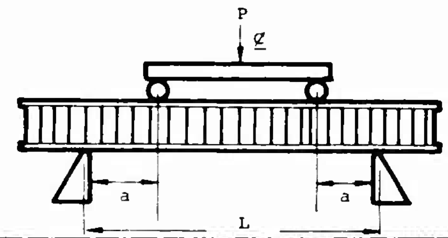
TABLE VIII . CONTINUED

Panel Number	Specimen Number	Panel Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Dimensions: Width (In.)	Thick. (In.)	Area, (In.^{2})	Test Temp (°F)	Ultimate Strength: Load (lb)	Stress (ksi)	Average Stress (ksi)	Modulus (10^6psi)	Average Modulus (10^6psi)	Type of Failure
L-14B	1		16	±45	A+B	0.495	0.122	0.0604	75	1830	30.3		3.61		d
	2		16	±45	A+B	0.484	0.121	0.0586	75	1790	30.55	30.44	3.50	3.1	d
	3		16	±45	A+B	0.485	0.113	0.0548	75	1670	30.47		2.19		d
	1		16	±45	A+B	0.484	0.122	0.0590	160	1100	18.64		1.31		d
	2		16	±45	A+B	0.495	0.111	0.0550	160	1050	19.09	18.35	2.21	1.76	d
	3		16	±45	A+B	0.489	0.122	0.060	160	1040	17.33		1.75		d
	1	XP251S	16	±45	A+B	0.499	0.120	0.060	-65	2225	37.08		2.198		d
	2		16	±45	A+B	0.499	0.123	0.061	-65	2350	38.52	39.00	2.498	2.71	d
	3		16	±45	A+B	0.493	0.118	0.058	-65	2400	41.38		3.422		d
	1		16	±45	A+B	0.486	0.121	0.059	75**	1550	26.27		2.702		d
	2		16	±45	A+B	0.493	0.121	0.060	75**	1600	26.67	26.54	5.533	3.31	d
	3		16	±45	A+B	0.490	0.123	0.060	75**	1600	26.67		1.70		d
L-13A	1		16	0	A	0.492	0.107	0.0526	75	4450	84.6		—		a,e
	2	XP251S	16	0	A	0.497	0.113	0.0562	75	6250	111.21	96.1	—	—	g
	3		16	0	A	0.497	0.112	0.0557	75	5150	92.46		—		a,e
L-13B	1		16	0	A+B	0.491	0.121	0.0594	75	4550	76.6		7.470		a,e
	2		16	0	A+B	0.500	0.115	0.0575	75	7700	133.91	112.06	4.850	5.85	a,e
	3		16	0	A+B	0.492	0.110	0.0541	75	6800	125.69		5.240		g
	1		16	0	A+B	0.483	0.123	0.0590	160	4150	70.34		0.460		g
	2		16	0	A+B	0.491	0.125	0.0610	160	4725	77.46	75.50	0.952	0.675	g
	3		16	0	A+B	0.485	0.112	0.0540	160	4250	78.70		0.613		g
	1	XP251S	16	0	A+B	0.491	0.119	0.0580	-65	7400	127.59		6.776		a,e
	2		16	0	A+B	0.486	0.112	0.0540	-65	5675	105.09	113.08	4.860	4.98	a,e
	3		16	0	A+B	0.488	0.125	0.0610	-65	6500	106.56		3.294		a,e
	1		16	0	A+B	0.485	0.121	0.0590	75**	7500	127.12		—		a,e
	2		16	0	A+B	0.497	0.113	0.0560	75**	5200	92.86	106.12	2.919	2.44	g
	3		16	0	A+B	0.492	0.126	0.0620	75**	6100	98.39		1.960		g
L-12A	1		12	±45	A	0.497	0.105	0.0522	75	1320	25.3		—		d
	2	1002S	12	±45	A	0.497	0.101	0.0502	75	1250	24.9	25.53	1.60	1.086	d
	3		12	±45	A	0.496	0.105	0.0521	75	1375	26.4		0.573		d
L-12B	1		12	±45	A+B	0.504	0.105	0.0529	75	1400	26.5		—		d
	2		12	±45	A+B	0.503	0.104	0.0523	75	1400	26.8	26.9	—	—	d
	3		12	±45	A+B	0.496	0.100	0.0496	75	1360	27.4		—		d
	1		12	±45	A+B	0.502	0.106	0.053	160	930	17.55		0.363		d,e
	2		12	±45	A+B	0.498	0.108	0.054	160	960	17.78	17.37	0.275	0.281	d
	3	1002S	12	±45	A+B	0.503	0.106	0.053	160	890	16.79		0.207		d
	1		12	±45	A+B	0.506	0.106	0.054	-65	1975	36.57		0.719		d
	2		12	±45	A+B	0.503	0.106	0.053	-65	1925	36.32	36.41	2.88	1.725	d
	3		12	±45	A+B	0.502	0.109	0.055	-65	2000	36.36		1.576		g
	1		12	±45	A+B	0.503	0.108	0.054	75**	1200	22.22		2.616		d
	2		12	±45	A+B	0.505	0.101	0.055	75**	1125	20.46	21.61	1.682	1.946	d
	3		12	±45	A+B	0.493	0.107	0.053	75**	1175	22.17		1.542		d

TABLE VIII. CONTINUED

Panel Number	Specimen Number	Panel Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick. (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Ultimate Strength: Load (lb)	Ultimate Strength: Stress (ksi)	Ultimate Strength: Average Stress (ksi)	Ultimate Strength: Modulus (10^6psi)	Ultimate Strength: Average Modulus (10^6psi)	Type of Failure
L-11A	1		12	0	A	0.499	0.102	0.0509	75	5400	106.1		—		g
	2	1002S	12	0	A	0.493	0.102	0.0503	75	5200	103.4	89.4	—	—	f
	3		12	0	A	0.495	0.1025	0.0507	75	2975	58.7		8.95		f
L-11B	1		12	0	A+B	0.487	0.102	0.0497	75	5000	100.6		—		a,e
	2		12	0	A+B	0.486	0.102	0.0496	75	4725	95.26	95.38	—	—	a,e
	3		12	0	A+B	0.478	0.098	0.0468	75	4225	90.28		—		f
	1		12	0	A+B	0.492	0.101	0.050	160	2900	58.0		0.422		b,e
	2		12	0	A+B	0.485	0.104	0.050	160	2475	49.5	56.07	0.421	0.403	a
	3	1002S	12	0	A+B	0.479	0.102	0.049	160	2975	60.71		0.367		a
	1		12	0	A+B	0.491	0.103	0.051	-65	4280	83.92		0.123		a
	2		12	0	A+B	0.496	0.101	0.050	-65	4650	93.0	89.31	0.553	0.365	a
	3		12	0	A+B	0.487	0.102	0.050	-65	4550	91.0		0.420		a
	1		12	0	A+B	0.507	0.105	0.053	75**	3875	73.11		5.174		g
	2		12	0	A+B	0.491	0.101	0.050	75**	4330	86.6	75.35	3.476	3.83	a,e
	3		12	0	A+B	0.495	0.099	0.049	75**	3250	66.33		2.836		g

TABLE IX. FLEXURAL PROPERTIES FOR SANDWICH BEAMS CONSTRUCTED OF ALUMINUM CORES AND LAMINATED EPOXY RESIN PANELS REINFORCED WITH (1) S-GLASS FIBERS AND (2) 143-STYLE FABRIC AND TESTED AT -65°F, 75°F, and 160°F.



Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
1-B1	8		4.4	AF126	4	0	B	1.991	0.024	0.0478	75	1100	99.445	10.94	c,d
	10		4.4	AF126	4	0	B	1.990	0.026	0.0517	75	1135	67.707	10.37	---
	6	XP251S	4.4	AF126	4	0	B	1.994	0.023	0.0458	160	900	84.084	10.75	c,d,g
	12		4.4	AF126	4	0	B	1.990	0.023	0.0457	160	870	82.700	11.58	c,d,g
	3		4.4	AF126	4	0	B	2.017	0.026	0.0524	-65	1150	94.153	9.85	c,d,g
1-B2	1		4.4	AF126	4	0	B	1.986	0.024	0.0476	75	1230	111.247	10.62	---
	13		4.4	AF126	4	0	B	1.985	0.026	0.0516	75	1150	96.154	9.83	---
	2		4.4	AF126	4	0	B	1.998	0.026	0.0519	75**	1240	102.910	10.02	c,g
	4	XP251S	4.4	AF126	4	0	B	2.001	0.024	0.0480	75**	1270	114.475	11.84	c,g
	8		4.4	AF126	4	0	B	1.992	0.028	0.0558	75**	1180	91.215	10.11	---
	12		4.4	AF126	4	0	B	1.992	0.023	0.0458	160	930	87.079	10.62	c,d
	6		4.4	AF126	4	0	B	1.987	0.026	0.0516	-65	1375	114.381	9.74	a
	10		4.4	AF126	4	0	B	1.993	0.022	0.0438	-65	1345	131.468	11.73	c,g,d
1-B4	1		4.4	AF126	4	0	B	2.002	0.024	0.0480	75*	1130	97.453	9.73	c,g
	3		4.4	AF126	4	0	B	2.031	0.024	0.0487	75*	1355	115.406	10.04	c,g
	5	XP251S	4.4	AF126	4	0	B	2.037	0.024	0.0489	75*	1260	106.695	10.09	c,g
	9		4.4	AF126	4	0	B	2.040	0.024	0.0490	-65*	1200	101.533	9.82	---
	11		4.4	AF126	4	0	B	2.039	0.024	0.0489	-65*	1260	106.779	9.19	---
	12		4.4	AF126	4	0	B	2.055	0.024	0.0493	-65*	1220	102.572	8.79	---

Cure
A - 1 hour at 330°-340°F at 30 psig
B - 2 hours at 330°-340°F at 30 psig+
16 hours postcure at 280°F, under vacuum pressure

Specimen Conditioning
** Specimen exposed to 120°F in condensing humidity chamber (100 percent humidity) for 30 days and tested within 30 minutes at specified temperature.
* Specimen artificially weathered for 300 hours and tested within 30 days at specified temperature.

(1) Scotchply XP251S and 1002S nonwoven organic prepreg
(2) BP907 - 143S woven organic prepreg
(3) Number of plies pertains to either tension or compression face of beam
(4) 143 fabric and unidirectional material laid up relative to core ribbon direction

Failure Type
a) Failure in compression face by debonding
c) Failure in compression face
d) Shear failure in core due to wrinkling
e) Adhesive bond failure
f) Shear failure in core accompanied by failure in adhesive between core and face
g) Edgewise shear
h) No failure

(*) Specimens exposed to actual climatic conditions encountered in the Mid-Atlantic region of the United States for a period of 15 months.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
1-C1	1	XP251S	4.4	AF126	4	0	B	1.982	0.023	0.0456	75	1320	119.974	10.11	c,g,d
	13		4.4	AF126	4	0	B	2.018	0.024	0.0484	75**	1475	125.929	11.54	c,d
	3		4.4	AF126	4	0	B	2.003	0.024	0.0481	160	1170	100.842	10.56	c,g
	5		4.4	AF126	4	0	B	2.006	0.024	0.0481	-65	1440	123.912	10.82	a,e
	7		4.4	AF126	4	0	B	2.013	0.024	0.0483	-65	1500	128.632	11.33	a,e
	9		4.4	AF126	4	0	B	2.014	0.024	0.0483	-65	1470	126.008	10.78	d,e
1-C2	1	XP251S	4.4	AF126	4	0	B	1.990	0.023	0.0457	75	940	85.163	10.24	c,g
	7		4.4	AF126	4	0	B	2.009	0.023	0.0462	75	1280	114.889	10.14	c,g
	4		4.4	AF126	4	0	B	2.006	0.024	0.0481	75**	1220	104.981	11.65	c,g
	9		4.4	AF126	4	0	B	2.011	0.024	0.0483	75**	1410	121.036	11.53	c,g
	3		4.4	AF126	4	0	B	2.008	0.024	0.0482	160	980	84.414	10.85	c,g
	6		4.4	AF126	4	0	B	2.010	0.024	0.0482	160	925	79.596	10.01	c,g
2-A1	11	XP251S	4.4	FM1000	4	0	A	1.994	0.024	0.0478	75	1360	117.983	10.65	c,d,g
	8		4.4	FM1000	4	0	A	1.994	0.024	0.0478	75**	1190	103.235	10.65	c,g
	10		4.4	FM1000	4	0	A	1.980	0.024	0.0475	160	820	71.487	9.56	c,g
	5		4.4	FM1000	4	0	A	1.983	0.025	0.0496	-65	1560	130.640	11.50	a,g
	7		4.4	FM1000	4	0	A	1.990	0.025	0.0497	-65	1500	125.270	10.13	a,g,f
	12		4.4	FM1000	4	0	A	1.990	0.025	0.0497	-65	1500	125.393	8.93	a,g
2-A2	9	XP251S	4.4	FM1000	4	0	A	2.019	0.026	0.0525	75	1250	103.699	9.84	c,g,d
	11		4.4	FM1000	4	0	A	2.028	0.024	0.0487	75	1110	94.672	10.47	c,g
	8		4.4	FM1000	4	0	A	2.022	0.026	0.0526	75**	1105	91.349	9.79	c,g
	12		4.4	FM1000	4	0	A	2.028	0.026	0.0527	75**	1220	100.777	10.92	c,g
	4		4.4	FM1000	4	0	A	2.014	0.024	0.0483	160	815	72.921	9.63	h
	10		4.4	FM1000	4	0	A	2.020	0.026	0.0525	160	760	62.889	9.52	e
2-B1	10	XP251S	4.4	FM1000	4	0	B	1.990	0.028	0.0557	75	1250	97.602	10.31	c,g
	4		4.4	FM1000	4	0	B	1.990	0.025	0.0497	160	870	75.382	10.18	h
	2		4.4	FM1000	4	0	B	2.000	0.024	0.0480	-65	1400	125.607	10.22	c,e,g
2-B2	9	XP251S	4.4	FM1000	4	0	B	1.989	0.026	0.0517	75	1210	98.761	10.05	d
	10		4.4	FM1000	4	0	B	1.990	0.026	0.0517	75	1300	106.148	10.07	f
	6		4.4	FM1000	4	0	B	2.030	0.026	0.0528	75**	1260	100.772	9.72	d
	8		4.4	FM1000	4	0	B	2.000	0.026	0.0520	75**	1235	99.843	9.79	c,g
	13		4.4	FM1000	4	0	B	2.010	0.026	0.0523	75**	1200	96.628	9.36	c,g
	7		4.4	FM1000	4	0	B	1.998	0.027	0.0539	160	960	75.277	8.77	c,g,d
	12		4.4	FM1000	4	0	B	1.997	0.027	0.0539	160	945	73.842	8.07	f
	2		4.4	FM1000	4	0	B	1.998	0.024	0.0479	-65	1390	121.279	9.94	c,e
	4		4.4	FM1000	4	0	B	1.998	0.025	0.0499	-65	1300	109.211	10.31	f

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orien-ta-tion (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area, (In.^{2})	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
2-B4 (1)	2	XP251S	4.4	FM1000	4	0		2.000	0.025	0.0500	75*	1190	98.683	9.50	c,g
	6		4.4	FM1000	4	0		2.025	0.025	0.0506	75*	1170	95.846	9.12	c,g
	8		4.4	FM1000	4	0		2.020	0.025	0.0505	75*	1160	95.247	9.01	c,g
	3		4.4	FM1000	4	0		2.012	0.024	0.0483	-65	1155	99.007	8.14	---
	5		4.4	FM1000	4	0		2.010	0.024	0.0482	-65	1125	96.513	8.84	---
	9		4.4	FM1000	4	0		2.020	0.024	0.0485	-65	1035	88.363	8.52	---
2-C1	10	XP251S	4.4	FM1000	4	0	B	1.985	0.024	0.0476	75	1275	113.079	10.93	f,g
	2		4.4	FM1000	4	0	B	2.000	0.026	0.0520	160	865	69.586	9.04	c,g
	4		4.4	FM1000	4	0	B	1.997	0.025	0.0499	-65	1290	108.542	10.18	e
	6		4.4	FM1000	4	0	B	2.000	0.026	0.0520	-65	1300	105.198	9.54	e
	8		4.4	FM1000	4	0	B	1.997	0.026	0.0519	-65	1285	104.461	9.45	c,e
2-C2	5	XP251S	4.4	FM1000	4	0	B	2.011	0.023	0.0462	75	1290	115.888	11.04	c,g
	7		4.4	FM1000	4	0	B	2.009	0.024	0.0482	75	1360	117.432	10.91	c,g,d
	6		4.4	FM1000	4	0	B	2.008	0.024	0.0482	75	1020	87.682	10.25	c,g
	10		4.4	FM1000	4	0	B	2.010	0.025	0.0503	75	1200	99.318	10.45	c,g
	9		4.4	FM1000	4	0	B	2.008	0.024	0.0482	160	1050	90.608	10.33	c,g
	11		4.4	FM1000	4	0	B	2.000	0.025	0.0500	160	1000	83.252	9.85	c,g
3-A1	1	BP907(2Ply) + XP251S (2 Ply)	4.4	AF126	4	±45	A	1.981	0.028	0.0554	75	465	34.799	4.23	h
	10		4.4	AF126	4	±45	A	2.014	0.028	0.0564	75**	410	30.090	3.85	h
	2		4.4	AF126	4	±45	A	2.005	0.028	0.0561	160	240	17.675	1.66	h
	4		4.4	AF126	4	±45	A	2.009	0.028	0.0562	-65	615	45.291	4.39	h
	6		4.4	AF126	4	±45	A	2.007	0.028	0.0562	-65	560	41.327	4.05	h
	8		4.4	AF126	4	±45	A	2.009	0.028	0.0562	-65	590	43.450	4.32	h
3-A2	2	BP907(2Ply) + XP251S (2 Ply)	4.4	AF126	4	±45	A	1.995	0.028	0.0559	75	450	33.435	3.84	h
	6		4.4	AF126	4	±45	A	2.000	0.028	0.0560	75	420	31.098	3.82	h
	4		4.4	AF126	4	±45	A	1.992	0.028	0.0557	75**	440	32.750	4.38	h
	8		4.4	AF126	4	±45	A	1.998	0.028	0.0559	75**	425	31.506	4.43	h
	1		4.4	AF126	4	±45	A	1.991	0.028	0.0557	160	260	19.362	2.16	h
	5		4.4	AF126	4	±45	A	1.996	0.028	0.0559	160	245	18.197	2.40	h
1-A1	8	XP251S	4.4	AF126	4	0	A	1.998	0.023	0.0459	75**	1130	106.770	11.20	c,e
	13		4.4	AF126	4	0	A	1.995	0.023	0.0458	75	1220	82.081	11.52	c,d
	10		4.4	AF126	4	0	A	2.005	0.023	0.0461	160	830	77.510	10.80	h
	2		4.4	AF126	4	0	A	2.003	0.024	0.0481	-65	1220	110.178	10.98	a,f

(1) - Panel 2-B4 cured for 3.5 hours at 330-340°F at 30 psig

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area ($In.^2$)	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
1-A2	1		4.4	AF126	4	0	A	1.992	0.023	0.0458	75	1280	115.745	9.87	c,g
	4		4.4	AF126	4	0	A	2.023	0.025	0.0506	75**	1270	104.139	10.58	c,g
	8		4.4	AF126	4	0	A	2.018	0.024	0.0484	75**	1540	131.982	11.08	c,g
	9	XP251S	4.4	AF126	4	0	A	2.000	0.024	0.0480	75	1400	120.935	10.18	c,g,d
	2		4.4	AF126	4	0	A	2.018	0.024	0.0484	160	990	84.931	10.40	c,g
	6		4.4	AF126	4	0	A	2.025	0.024	0.0486	160	990	84.641	10.23	c,g
3-B1 (2)	1	BP907(2Ply)	4.4	AF126	4	±45		1.987	0.035	0.0695	75	420	24.680	3.36	h
	2	+	4.4	AF126	4	±45		2.005	0.039	0.0782	160	250	13.103	1.50	h
	8	XP251S (2 Ply)	4.4	AF126	4	±45		2.020	0.039	0.0788	-65	625	32.577	3.00	h
3-B2 (2)	1		4.4	AF126	4	±45		1.999	0.037	0.0740	75	425	23.596	3.19	h
	2		4.4	AF126	4	±45		1.996	0.037	0.0738	75	440	24.489	2.67	h
	8	BP907(2Ply)	4.4	AF126	4	±45		2.009	0.035	0.0703	75**	390	22.644	3.60	h
	10	+	4.4	AF126	4	±45		2.011	0.039	0.0784	75**	385	20.158	3.26	h
	12		4.4	AF126	4	±45		2.005	0.037	0.0742	75**	410	22.738	2.93	h
	3	XP251S	4.4	AF126	4	±45		2.006	0.039	0.0782	160	240	12.571	1.59	h
	6	(2 Ply)	4.4	AF126	4	±45		2.007	0.039	0.0782	160	240	12.568	1.33	h
	4		4.4	AF126	4	±45		2.004	0.039	0.0781	-65	620	32.606	2.86	h
	11		4.4	AF126	4	±45		2.005	0.039	0.0782	-65	625	32.823	2.85	h
3-B4 (3)	2		4.4	AF126	4	±45		2.025	0.043	0.0871	75*	460	21.548	2.60	h
	6	BP907(2Ply)	4.4	AF126	4	±45		2.040	0.039	0.0795	75*	455	23.303	3.00	h
	8	+	4.4	AF126	4	±45		2.045	0.043	0.0879	75*	450	20.872	2.59	h
	3	XP251S	4.4	AF126	4	±45		2.040	0.039	0.0796	-65**	630	32.237	2.43	---
	5	(2 Ply)	4.4	AF126	4	±45		2.041	0.041	0.0837	-65**	625	30.494	2.91	---
	9		4.4	AF126	4	±45		2.039	0.039	0.0795	-65**	630	32.254	2.97	---
3-C1 (2)	1		4.4	AF126	4	±45		1.984	0.037	0.0734	75	480	26.670	2.79	h
	4	BP907(2Ply)	4.4	AF126	4	±45		2.030	0.039	0.0792	75**	410	21.144	3.05	h
	2	+	4.4	AF126	4	±45		2.013	0.039	0.0785	160	400	20.842	2.16	h
	6	XP251S	4.4	AF126	4	±45		2.021	0.040	0.0808	-65	690	34.914	3.14	h
	8	(2 Ply)	4.4	AF126	4	±45		2.020	0.042	0.0848	-65	690	33.333	3.00	h
	10		4.4	AF126	4	±45		2.025	0.040	0.0810	-65	690	34.846	3.05	h
3-C2 (3)	5		4.4	AF126	4	±45		2.017	0.035	0.0706	75	450	26.151	2.60	h
	8	BP907(2Ply)	4.4	AF126	4	±45		2.022	0.037	0.0748	75	460	25.296	2.64	h
	1	+	4.4	AF126	4	±45		2.020	0.035	0.0707	75**	413	23.987	3.40	h
	3	XP251S	4.4	AF126	4	±45		2.020	0.035	0.0707	75**	400	23.231	3.16	h
	7	(2 Ply)	4.4	AF126	4	±45		2.026	0.037	0.0749	160	285	15.610	2.63	h
	9		4.4	AF126	4	±45		2.025	0.037	0.0749	160	310	17.005	2.16	h

(2) Panels 3-B1, 3-B2, and 3-C1 cured for 1/2 hour at 180-190°F at 30 psig, 1/2-hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 50 psig, 16 hours postcure at 280°F, under vacuum pressure.

(3) Panels 3-B4 and 3-C2 cured for 1/2 hour at 180-190°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
4-A1	1		4.4	AF126	4	±45	A	1.998	0.031	0.0619	75	430	29.017	2.86	h
	12		4.4	AF126	4	±45	A	1.990	0.033	0.0657	75**	310	19.611	2.89	h
	4	BP907(2Ply)	4.4	AF126	4	±45	A	1.998	0.033	0.0659	160	185	11.891	1.28	h
	6	+	4.4	AF126	4	±45	A	2.021	0.031	0.0626	-65	690	46.489	4.10	h
	8	XP251S	4.4	AF126	4	±45	A	2.020	0.031	0.0626	-65	690	46.415	3.87	h
	10	(2 Ply)	4.4	AF126	4	±45	A	2.025	0.031	0.0628	-65	690	46.080	3.71	h
4-A2	11		4.4	AF126	4	±45	A	1.981	0.031	0.0614	75	380	25.910	3.11	h
	13	BP907(2Ply)	4.4	AF126	4	±45	A	2.000	0.031	0.0620	75	390	26.790	3.98	h
	4	+	4.4	AF126	4	±45	A	1.996	0.031	0.0619	75**	303	20.610	3.01	h
	12	XP251S	4.4	AF126	4	±45	A	2.014	0.031	0.0629	75**	298	20.309	3.16	h
	2	(2 Ply)	4.4	AF126	4	±45	A	1.988	0.031	0.0616	160	180	12.504	1.66	h
	10		4.4	AF126	4	±45	A	1.996	0.031	0.0619	160	185	12.722	1.83	h
4-B1 (2)	10	BP907(2Ply)	4.4	AF126	4	±45		2.029	0.035	0.0710	75	450	25.897	4.13	h
	12	+	4.4	AF126	4	±45		2.017	0.035	0.0706	160	260	15.067	1.94	h
	8	XP251S (2 Ply)	4.4	AF126	4	±45		2.021	0.035	0.0707	-65	665	38.500	3.60	h
4-B2 (2)	1	BP907(2 Ply)	4.4	AF126	4	±45		2.022	0.039	0.0788	75	455	23.652	3.57	h
	3		4.4	AF126	4	±45		2.020	0.039	0.0788	75	440	22.891	3.57	h
	2		4.4	AF126	4	±45		2.043	0.039	0.0797	75**	415	21.371	3.41	h
	4		4.4	AF126	4	±45		2.043	0.039	0.0797	75**	405	20.755	2.74	h
	6	+	4.4	AF126	4	±45		2.042	0.039	0.0796	75**	400	20.549	3.06	h
	5		4.4	AF126	4	±45		2.014	0.039	0.0785	160	250	13.072	1.76	h
	7		4.4	AF126	4	±45		2.018	0.039	0.0787	160	260	13.553	1.50	h
	9	XP251S	4.4	AF126	4	±45		2.010	0.039	0.0784	-65	600	31.400	2.31	---
	11	(2 Ply)	4.4	AF126	4	±45		2.026	0.039	0.0790	-65	625	32.453	2.98	---
4-B4 (3)	2	BP907(2Ply)	4.4	AF126	4	±45		2.025	0.043	0.0871	75*	470	22.018	2.80	h
	4		4.4	AF126	4	±45		2.030	0.041	0.0832	75*	465	22.789	2.87	h
	6	+	4.4	AF126	4	±45		2.029	0.043	0.0872	75*	470	21.975	2.81	h
	8		4.4	AF126	4	±45		2.030	0.039	0.0792	-65**	680	34.967	2.77	---
	10	XP251S	4.4	AF126	4	±45		2.010	0.039	0.0784	-65**	675	35.057	2.80	---
	11	(2 Ply)	4.4	AF126	4	±45		2.014	0.039	0.0785	-65**	655	33.952	2.87	---

(2) - Panels 4-B1, 4-B2, and 4-C1 cured for 1/2 hour at 180-190°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 50 psig, 16 hours postcure at 280°F, under vacuum pressure.

(3) - Panels 4-B4 and 4-C2 cured for 1/2 hour 180-190°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area ($In.^2$)	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
4-C1 (2)	2	BP907(2Ply)	4.4	AF126	4	±45		1.976	0.039	0.0771	75	440	23.401	2.89	h
	12		4.4	AF126	4	±45		1.995	0.039	0.0778	75**	408	21.514	2.95	h
	3	+	4.4	AF126	4	±45		1.975	0.037	0.0731	160	290	16.281	2.15	h
	1		4.4	AF126	4	±45		1.972	0.035	0.0690	-65	590	35.104	3.20	---
	7	XP251S	4.4	AF126	4	±45		1.962	0.037	0.0726	-65	590	33.344	2.98	---
	11	(2 Ply)	4.4	AF126	4	±45		1.976	0.037	0.0731	-65	600	33.668	3.05	---
4-C2 (3)	6	BP907(2Ply)	4.4	AF126	4	±45		2.010	0.037	0.0744	75	430	23.768	3.13	h
	8		4.4	AF126	4	±45		2.007	0.037	0.0743	75	430	23.805	3.01	h
	2	+	4.4	AF126	4	±45		2.030	0.039	0.0792	75**	397	20.571	2.93	h
	4	XP251S	4.4	AF126	4	±45		2.033	0.039	0.0793	75**	390	20.201	2.95	h
	7	(2 Ply)	4.4	AF126	4	±45		2.011	0.037	0.0744	160	275	15.179	1.91	h
	9		4.4	AF126	4	±45		2.007	0.037	0.0743	160	285	15.792	2.22	h
5-A1 (4)	1	BP907(2 Ply)	4.4	None	8	±45		1.981	0.066	0.1307	75	890	27.190	2.85	h
	4	+	4.4	None	8	±45		2.007	0.065	0.1305	160	660	20.173	2.25	h
	2	1002S(4 Ply)	4.4	None	8	±45		2.004	0.065	0.1303	-65	1310	40.210	3.01	h
	6	+	4.4	None	8	±45		2.018	0.065	0.1312	-65	1390	42.290	2.93	h
	8	BP907(2 Ply)	4.4	None	8	±45		2.020	0.065	0.1313	-65	1210	36.777	2.92	h
5-A2 (4)	2	BP907(2 Ply)	4.4	None	8	±45		2.025	0.063	0.1276	75	835	26.121	2.81	h
	12	+	4.4	None	8	±45		2.014	0.063	0.1269	75	835	26.287	2.79	h
	4	1002S(4 Ply)	4.4	None	8	±45		2.024	0.063	0.1275	75**	730	22.912	2.49	h
	13	+	4.4	None	8	±45		2.024	0.065	0.1316	75**	690	20.951	2.84	h
	1	BP907(2 Ply)	4.4	None	8	±45		2.025	0.063	0.1276	160	610	19.066	2.03	h
	10		4.4	None	8	±45		2.010	0.065	0.1307	160	625	19.110	2.28	h
5-B1 (5)	1	BP907(2Ply)+	4.4	None	8	±45		1.990	0.072	0.1433	75	920	25.410	2.46	h
	7	1002S(4Ply)+	4.4	None	8	±45		2.005	0.075	0.1504	160	690	18.142	1.86	h
	9	BP907(2Ply)	4.4	None	8	±45		2.006	0.075	0.1505	-65	1290	33.931	2.39	h
	4		4.4	None	8	±45		2.016	0.077	0.1552	75	965	24.532	2.71	h
	6	BP907(2 Ply)	4.4	None	8	±45		2.016	0.077	0.1552	75	970	24.658	2.65	h
	10	+	4.4	None	8	±45		2.026	0.075	0.1520	75**	930	24.176	2.59	h
	11	1002S(4 Ply)	4.4	None	8	±45		2.024	0.075	0.1518	75**	840	21.838	2.39	h
	12	+	4.4	None	8	±45		2.024	0.075	0.1518	75**	835	21.728	2.36	h
	2	BP907(2 Ply)	4.4	None	8	±45		2.016	0.077	0.1552	160	640	16.286	1.90	h
	9		4.4	None	8	±45		2.028	0.077	0.1562	160	630	15.937	1.79	h
	8		4.4	None	8	±45		2.024	0.077	0.155[illegible]	-65	1300	32.920	2.33	---

(2) - Panels 4-B1, 4-B2, and 4-C1 cured for 1/2 hour at 180-190°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 50 psig, 16 hours postcure at 280°F, under vacuum pressure.

(3) - Panels 4-B4 and 4-C2 cured for 1/2 hour at 180-190°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

(4) - Panels 5-A1 and 5-A2 cured for 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 275-285°F at 30 psig, 7 hours at 330-340°F at 30 psig.

(5) - Panels 5-B1, 5-B2 and 5-B4 cured for 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area ($In.^2$)	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
5-B4 (5)	2	BP907(2 Ply)	4.4	None	8	±45		2.044	0.075	0.1553	75*	970	25.017	2.50	h
	6	+	4.4	None	8	±45		2.045	0.072	0.1472	75*	960	25.802	2.73	h
	8	1002S(4 Ply)	4.4	None	8	±45		2.045	0.072	0.1472	75*	975	26.180	2.64	h
	3	+	4.4	None	8	±45		2.038	0.075	0.1529	-65*	1340	34.692	2.29	---
	5	BP907(2 Ply)	4.4	None	8	±45		2.038	0.075	0.1529	-65*	1340	34.692	2.28	---
	9		4.4	None	8	±45		2.024	0.075	0.1518	-65*	1340	34.695	2.33	---
5-C1 (6)	6	BP907(2 Ply)	4.4	None	8	±45		1.985	0.079	0.1568	75	970	24.299	2.37	h
	8	+	4.4	None	8	±45		1.985	0.079	0.1568	75	960	24.070	2.22	h
	10	1002S(4 Ply)	4.4	None	8	±45		1.985	0.079	0.1568	75	960	24.070	2.60	h
	4	+	4.4	None	8	±45		2.008	0.079	0.1586	75**	810	20.077	2.14	h
	7	BP907(2 Ply)	4.4	None	8	±45		2.010	0.079	0.1588	75**	810	20.056	2.16	h
	1		4.4	None	8	±45		1.959	0.979	0.1548	160	560	14.252	1.54	---
	3		4.4	None	8	±45		1.961	0.079	0.1549	160	565	14.339	1.55	---
	12		4.4	None	8	±45		1.961	0.079	0.1549	160	520	13.221	1.60	---
	9		4.4	None	8	±45		1.890	0.079	0.1493	-65	1200	31.599	2.35	h
	11		4.4	None	8	±45		1.891	0.079	0.1494	-65	1195	31.453	2.35	h
	13		4.4	None	8	±45		1.894	0.079	0.1496	-65	1220	32.119	2.38	h
5-C2 (6)	10	BP907(2Ply)+ 1002S(4Ply)+ BP907(2Ply)	4.4	None	8	±45		2.010	0.083	0.1668	75**	825	19.514	2.10	h
6-1 (7)	7		4.4	FM1000	3	0		2.020	0.025	0.0505	75	1055	61.756	7.95	a,e
	8	1002S	4.4	FM1000	3	0		2.015	0.025	0.0504	75	1030	59.745	8.39	e
	9		4.4	FM1000	3	0		2.017	0.025	0.0504	75	1200	70.012	8.19	a,e
6-2 (8)	2		4.4	FM1000	3	0		2.015	0.030	0.0604	75	1390	94.429	8.16	e
	8		4.4	FM1000	3	0		2.009	0.031	0.0623	75	1400	92.679	8.63	i
	1		4.4	FM1000	3	0		2.008	0.032	0.0643	160	1230	78.692	7.79	c,g
	4		4.4	FM1000	3	0		2.013	0.031	0.0624	160	1315	86.620	8.23	c,g,d
	7		4.4	FM1000	3	0		2.018	0.030	0.0605	160	755	51.014	8.63	c,g
	10	1002S	4.4	FM1000	3	0		2.020	0.031	0.0626	160	1270	83.449	8.44	c,g
	12		4.4	FM1000	3	0		2.015	0.032	0.0645	160	1220	77.923	7.99	c,g
	3		4.4	FM1000	3	0		2.010	0.031	0.0623	-65	1420	93.769	9.40	d,f
	5		4.4	FM1000	3	0		2.015	0.032	0.0645	-65	1450	92.613	8.40	d,f
	6		4.4	FM1000	3	0		2.010	0.031	0.0623	-65	1500	98.960	8.66	d,f
	9		4.4	FM1000	3	0		2.018	0.031	0.0626	-65	1490	98.102	8.26	i,f
	11		4.4	FM1000	3	0		2.014	0.031	0.0624	-65	1530	100.939	8.26	i,f

(5) - Panels 5-B1 and 5-B4 cured for 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

(6) - Panels 5-C1 and 5-C2 cured for 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1 hour at 330-340°F at 30 psig, 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig.

(7) - Panel 6-1 cured for 1 hour at 330-340°F at 50 psig, vented, 16 hours post cure at 280°F, under vacuum pressure.

(8) - Panels 6-2, 7-1, 7-2, 8-1, and 8-2 cured for 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area ($In.^2$)	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
7-1	2		4.4	FM1000	4	±45		1.995	0.035	0.0698	75	650	27.569	2.94	h
(8)	8		4.4	FM1000	4	±45		1.990	0.035	0.0696	75	615	26.201	3.29	h
	10		4.4	FM1000	4	±45		1.989	0.035	0.0696	75	630	26.801	3.17	h
	4	1002S	4.4	FM1000	4	±45		1.992	0.035	0.0697	160	235	14.143	1.38	h
	7		4.4	FM1000	4	±45		1.990	0.035	0.0696	160	220	13.253	1.58	h
	12		4.4	FM1000	4	±45		1.989	0.035	0.0696	160	225	14.081	1.47	h
	3		4.4	FM1000	4	±45		1.993	0.036	0.0717	-65	580	33.991	2.59	h
	6		4.4	FM1000	4	±45		1.984	0.035	0.0694	-65	575	34.777	3.17	h
7-2	2		4.4	FM1000	4	±45		2.023	0.033	0.0668	75	400	24.778	2.91	h
(8)	8		4.4	FM1000	4	±45		2.023	0.035	0.0708	75	390	22.865	2.60	h
	1		4.4	FM1000	4	±45		2.006	0.033	0.0662	160	225	14.081	2.34	h
	5	1002S	4.4	FM1000	4	±45		2.019	0.035	0.0707	160	240	14.085	1.42	h
	3		4.4	FM1000	4	±45		2.023	0.035	0.0708	-65	640	37.409	3.02	h
	6		4.4	FM1000	4	±45		2.022	0.034	0.0687	-65	600	36.124	3.59	h
	9		4.4	FM1000	4	±45		2.023	0.032	0.0647	-65	630	40.203	4.34	h
8-1	3		4.4	FM1000	4	0		1.992	0.024	0.0478	75	1245	80.376	11.79	d,i
(8)	4		4.4	FM1000	4	0		1.997	0.026	0.0519	75	1230	73.266	10.71	d
	5		4.4	FM1000	4	0		1.996	0.026	0.0519	75	1220	72.707	10.39	d
	2	XP251S	4.4	FM1000	4	0		1.996	0.026	0.0519	160	850	71.196	9.35	c,g
	7		4.4	FM1000	4	0		1.992	0.024	0.0478	160	1000	90.638	10.39	c,g,i
	10		4.4	FM1000	4	0		1.995	0.024	0.0479	160	950	85.795	10.77	c,g
	1		4.4	FM1000	4	0		1.995	0.023	0.0459	-65	1370	128.475	12.77	c,g,i
	6		4.4	FM1000	4	0		2.000	0.024	0.0480	-65	1240	112.271	10.28	c,g,i
8-2	2		4.4	FM1000	4	0		2.019	0.028	0.0565	75	1210	88.679	9.70	---
(8)	8		4.4	FM1000	4	0		2.020	0.026	0.0525	75	1280	101.059	9.71	---
	1		4.4	FM1000	4	0		2.014	0.027	0.0544	160	1120	85.335	11.80	c,g
	5	XP251S	4.4	FM1000	4	0		2.019	0.027	0.0545	160	1340	101.533	10.01	d
	3		4.4	FM1000	4	0		2.015	0.027	0.0544	-65	1540	116.708	10.09	c,f,d
	6		4.4	FM1000	4	0		2.020	0.027	0.0545	-65	1485	112.240	10.58	f
	9		4.4	FM1000	4	0		2.019	0.024	0.0485	-65	1455	124.296	1034	c,g,i
9-1	2		4.4	FM1000	4	±45		2.003	0.027	0.0541	75	355	27.352	3.75	h
(8)	7		4.4	FM1000	4	±45		2.012	0.027	0.0543	75	345	26.362	4.16	h
	11		4.4	FM1000	4	±45		2.009	0.027	0.0542	75	355	27.249	3.29	h
	1	XP251S	4.4	FM1000	4	±45		1.998	0.028	0.0559	160	205	15.256	3.07	h
	5		4.4	FM1000	4	±45		2.011	0.028	0.0563	160	200	14.775	3.68	h
	9		4.4	FM1000	4	±45		2.010	0.028	0.0563	160	205	15.163	2.74	h
	3		4.4	FM1000	4	±45		2.009	0.027	0.0542	-65	535	40.983	5.59	h
	6		4.4	FM1000	4	±45		2.009	0.030	0.0603	-65	530	36.644	5.45	h

(8) - Panels 6-2, 7-1, 7-2, 8-1, and 8-2 and 9-1 cured for 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
9-2 (8)	3	XP251S	4.4	FM1000	4	±45		2.009	0.026	0.0562	75	365	26.988	4.42	h
	8		4.4	FM1000	4	±45		2.002	0.027	0.0541	75	365	28.113	4.13	h
	2		4.4	FM1000	4	±45		2.001	0.029	0.0580	160	200	14.363	3.05	h
	4		4.4	FM1000	4	±45		2.000	0.029	0.0580	160	210	15.086	3.10	h
	5		4.4	FM1000	4	±45		2.002	0.028	0.0561	-65	520	38.623	4.21	h
	7		4.4	FM1000	4	±45		2.002	0.029	0.0581	-65	540	38.728	5.19	h
	9		4.4	FM1000	4	±45		2.002	0.030	0.0601	-65	540	37.463	4.84	h
10-1	1	BP907/ 1437	4.4	None	2	0		1.993	0.016	0.0319	75	640	83.899	7.72	c,g,i
	2		4.4	None	2	0		1.998	0.016	0.0320	75	665	86.962	7.67	c,g,i,e
	3		4.4	None	2	0		2.007	0.016	0.0321	75	680	88.515	7.46	c,g,i
	6		4.4	None	2	0		2.002	0.014	0.0280	160	445	66.500	---	---
	9		4.4	None	2	0		2.003	0.016	0.0320	160	460	60.247	7.72	---
	12		4.4	None	2	0		2.002	0.014	0.0280	160	465	69.488	10.50	---
	4		4.4	None	2	0		1.990	0.015	0.0298	-65	875	123.015	9.25	c,i,g,e
	[illegible]		4.4	None	2	0		1.998	0.016	0.0320	-65	820	107.761	8.19	c,i
10-2 (9)	[illegible]	BP907/ 1437	4.4	None	2	0		1.981	0.016	0.0317	75	620	81.782	7.76	---
	[illegible]		4.4	None	2	0		2.007	0.016	0.0321	75	545	71.160	6.31	---
	[illegible]		4.4	None	2	0		2.006	0.017	0.0341	160	460	56.552	7.43	c,g
	[illegible]		4.4	None	2	0		2.006	0.017	0.0341	160	430	52.803	7.23	c,g
	[illegible]		4.4	None	2	0		2.005	0.016	0.0321	-65	965	125.844	7.58	c,i,g
	4		4.4	None	2	0		2.007	0.016	0.0321	-65	980	127.682	8.52	c,i,g,
	6		4.4	None	2	0		2.005	0.016	0.0321	-65	840	109.543	7.46	c,i,g
733 (10)	2	BP907/ 1437	4.4	None	2	±45		1.997	0.020	0.0399	75	260	27.130	2.47	---
	6		4.4	None	2	±45		1.995	0.020	0.0399	75	240	25.068	2.07	---
	13		4.4	None	2	±45		1.998	0.020	0.0399	75	250	26.074	2.04	---

(8) - Panel 9-2 cured for 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

(9) - Panel 10-2 cured for 1/2 hour at 175-185°F at 30 psig, 1/2 hour at 280-290°F at 30 psig, 1 hour at 330-340°F at 30 psig, 16 hours postcure at 280°F, under vacuum pressure.

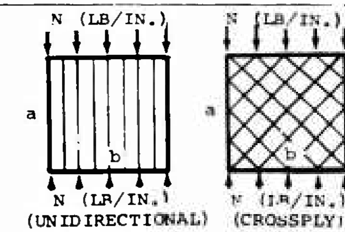
(10) - See section on beam fabrication for cure cycle.

TABLE IX. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(3) No. of Plies	(4) Ply Orientation (Deg)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexural Strength: Load (lb)	Flexural Strength: Stress (ksi)	Flexural Strength: Bending Modulus (10^6 psi)	Type of Failure
1-B1	3	XP251S	4.4	AF126	4	0	B	1.996	0.024	0.0479	75*	1240	90.757	11.90	c,g
1-B3	9	XP251S	4.4	AF126	4	0	B	2.011	0.021	0.0422	75*	1335	108.060	12.41	c,g
1-B4	7	XP251S	4.4	AF126	4	0	B	2.039	0.024	0.0489	75*	1320	93.730	10.93	c,g
2-B1	6	XP251S	4.4	FM1000	4	0	B	1.996	0.024	0.0479	75*	1320	99.547	10.93	c,g
2-B1	8	XP251S	4.4	FM1000	4	0	B	1.994	0.024	0.0478	75*	1265	96.083	10.82	c,g
2-B3	7	XP251S	4.4	FM1000	4	0	B	2.006	0.024	0.0481	75*	1380	99.793	11.28	c,g
3-B1	4	BP907 XP251S	4.4	AF126	2 2	+45 $\pm$45	(2)	2.003	0.038	0.0761	75*	374	16.603	2.66	h

TABLE X. PROPERTIES OF FIBER GLASS[(1)] SANDWICH PANELS AND ALUMINUM CORE[(2)] UNDER EDGEWISE COMPRESSIVE LOADS AND TESTED AT -65°F, 75°F, AND 160°F.

CORE RIBBON DIRECTION



a = 2.00 inches
b = 2.00 inches
Core Thickness=1.00

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft³)	Material: Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions: Width (In.)	Dimensions: (4) Length (In.)	Dimensions: Thick (In.)	Test Temp (°F)	Compressive Strength: Max Load (Lb)	Compressive Strength: Max Stress (ksi)
5C-2 (6)	7	BP907(2 Ply)	4.4	None	8	±45		1.991	2.000(4)	0.081	75	8800	27.283
	8	+	4.4	None	8	±45		1.990	2.000(4)	0.081	75	9000	27.917
	9	1002S(4 Ply)	4.4	None	8	±45		1.987	2.000(4)	0.081	75	8800	27.338
	1	+	4.4	None	8	±45		1.996	2.000(4)	0.081	75**	6550	20.257
	2	BP907(2 Ply)	4.4	None	8	±45		1.992	2.000(4)	0.081	75**	6625	20.530
	3		4.4	None	8	±45		1.991	2.000(4)	0.081	75**	6725	20.850
5C-2 (6)	10	BP907(2 Ply) +	4.4	None	8	±45		1.982	1.990	0.081	160	5210	16.226
	11	1002S(4 Ply)	4.4	None	8	±45		1.979	2.001	0.081	160	5670	17.686
	12	+ BP907(2 Ply)	4.4	None	8	±45		1.979	2.003	0.081	160	5600	17.467
5C-2 (6)	4	BP907(2 Ply) +	4.4	None		±45		1.989	2.000(4)	0.081	-65	12400	38.483
	5	1002S(4 Ply)	4.4	None		±45		1.991	2.000(4)	0.081	-65	12700	39.375
	6	+ BP907(2 Ply)	4.4	None		±45		1.987	2.000(4)	0.081	-65	13050	40.541
5B-3 (5)	1		4.4	None	8	±45		2.020	2.036	0.077	75	8450	27.163
	3	BP907(2 Ply)	4.4	None	8	±45		2.021	2.035	0.077	75	8225	26.429
	5	+	4.4	None	8	±45		2.026	2.027	0.077	75	7900	25.321
	2	1002S(4 Ply)	4.4	None	8	±45		2.026	2.000(4)	0.077	75**	6200	19.872
	3	+	4.4	None	8	±45		2.023	2.000(4)	0.077	75**	6300	20.222
	4	BP907(2 Ply)	4.4	None	8	±45		2.024	2.000(4)	0.077	75**	6300	20.213
	4		4.4	None	8	±45		2.025	2.000(4)	0.077	75*	8100	25.975
	4		4.4	None	8	±45		2.020	2.000(4)	0.077	75*	8000	25.717
	5		4.4	None	8	±45		2.025	2.000(4)	0.077	75*	7900	25.334

(1) Panels fabricated with Scotchply epoxy resin XP251S and 1002S (nonwoven organic prepreg) and BP907-143S (woven organic prepreg).
(2) 5052 Aluminum, 4.4 lb/ft³ density and 3/16 inch cell.
(3) Cure cycles and manufacturing processes are identical for the 2 inch x 2 inch compression sandwich squares with the sandwich long beam fabrication shown in Table XV. See Table XV for explanation of notes regarding different cures as shown under panel number.
(4) A portion of lengths were assumed to be 2.000 inches.
(5) Number of plies pertains to one face plate.
(6) 143 Fabric and unidirectional material laid up relative to core ribbon direction.
* Specimen artificially weathered for 300 hours and tested within 30 days after removal at specified temperature.
** Specimen conditioned at 120°F (100 percent R.H.) for 30 days and tested within 30 minutes after removal at 75°F.

TABLE X . CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions: Width (In.)	Dimensions: (4) Length (In.)	Dimensions: Thick (In.)	Test Temp (°F)	Compressive Strength: Max Load (Lb)	Compressive Strength: Max Stress (ksi)
5B-3 (5)	1	BP907(2 Ply) + 1002S(4 Ply) + BP907(2 Ply)	4.4	None	8	±45		2.016	2.033	0.077	160	6125	19.729
	2		4.4	None	8	±45		2.021	2.036	0.077	160	6000	19.279
	3		4.4	None	8	±45		2.023	2.037	0.077	160	5850	18.778
5B-3 (5)	2	BP907(2 Ply) + 1002S(4 Ply) + BP907(2 Ply)	4.4	None	8	±45		2.024	2.036	0.077	-65	10000	32.084
	3		4.4	None	8	±45		2.022	2.036	0.077	-65	10000	32.115
	5		4.4	None	8	±45		2.016	2.022	0.077	-65	10000	32.211
	1		4.4	None	8	±45		2.014	2.000(4)	0.077	-65*	12675	40.867
	2		4.4	None	8	±45		2.020	2.000(4)	0.077	-65*	11700	37.611
	5		4.4	None	8	±45		2.022	2.003	0.077	-65*	11900	38.217
5A-2 (4)	1	BP907(2 Ply) + 1002S(4 Ply) + BP907(2 Ply)	4.4	None	8	±45		2.022	1.992	0.063	75	7600	29.831
	2		4.4	None	8	±45		2.020	1.990	0.063	75	7200	28.289
	3		4.4	None	8	±45		2.017	1.993	0.063	75	7675	30.200
	1		4.4	None	8	±45		2.022	1.990	0.063	75**	6400	25.121
	2		4.4	None	8	±45		2.022	1.996	0.063	75**	6400	25.121
	3		4.4	None	8	±45		2.021	1.985	0.063	75**	6200	24.348
5A-2 (4)	1	BP907(2 Ply) + 1002S(4 Ply) + BP907(2 Ply)	4.4	None	8	±45		2.016	1.992	0.063	160	5400	21.259
	2		4.4	None	8	±45		2.022	1.983	0.063	160	5350	20.999
	3		4.4	None	8	±45		2.029	1.993	0.063	160	5600	21.905
5A-2 (4)	1	BP907(2 Ply) + 1002S(4 Ply) + BP907(2 Ply)	4.4	None	8	±45		2.016	1.985	0.063	-65	10000	39.369
	2		4.4	None	8	±45		2.021	1.986	0.063	-65	10000	39.271
	3		4.4	None	8	±45		2.019	1.980	0.063	-65	10000	39.310
4C-2 (3)	1	BP907(2 Ply) + XP251S(2 Ply)	4.4	AF-126	4	±45		2.010	2.000(4)	0.037	75	4125	27.733
	2		4.4	AF-126	4	±45		2.010	2.000(4)	0.037	75	4300	28.910
	3		4.4	AF-126	4	±45		2.008	2.000(4)	0.037	75	4175	28.097
	1		4.4	AF-126	4	±45		2.010	2.000(4)	0.037	75**	3450	23.195
	2		4.4	AF-126	4	±45		2.010	2.000(4)	0.037	75**	3325	22.354
	3		4.4	AF-126	4	±45		1.998	2.000(4)	0.037	75**	3450	23.334
4C-2 (3)	1	BP907(2 Ply) + XP251S(2 Ply)	4.4	AF-126	4	±45		2.010	2.000(4)	0.039	160	2525	16.105
	2		4.4	AF-126	4	±45		2.003	2.000(4)	0.039	160	2650	16.962
	3		4.4	AF-126	4	±45		1.990	2.000(4)	0.039	160	2560	16.493
4C-2 (3)	1	BP907(2 Ply) + XP251S(2 Ply)	4.4	AF-126	4	±45		2.002	2.000(4)	0.037	-65	5450	36.790
	2		4.4	AF-126	4	±45		2.009	2.000(4)	0.037	-65	5650	38.006
	3		4.4	AF-126	4	±45		2.008	2.000(4)	0.037	-65	5350	36.005

TABLE X . CONTINUED

Panel Number	Specimen Number	Mater Face Material	Co (Lb/Ft^3)	Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions Width (In.)	(4) Length (In.)	Thick (In.)	Test Temp (°F)	Compressive Strength Max Load (Lb)	Max Stress (ksi)
4B-3	13		4.4	AF-126	4	±45		2.006	2.000(4)	0.043	75	4550	26.375
(2)	14		4.4	AF-126	4	±45		2.004	2.000(4)	0.043	75	4525	26.256
	15		4.4	AF-126	4	±45		2.006	2.000(4)	0.043	75	4550	26.375
	1	BP907(2 Ply)	4.4	AF-126	4	±45		2.019	2.000(4)	0.043	75**	3575	20.590
	2	+	4.4	AF-126	4	±45		2.017	2.000(4)	0.043	75**	3550	20.466
	3	XP251S(2 Ply)	4.4	AF-126	4	±45		2.005	2.000(4)	0.043	75**	3550	20.558
	4		4.4	AF-126	4	±45		2.006	2.000(4)	0.043	75*	4225	24.491
	6		4.4	AF-126	4	±45		2.004	2.000(4)	0.043	75*	4100	23.790
	8		4.4	AF-126	4	±45		2.003	2.000(4)	0.043	75*	4150	24.093
4B-3	1	BP907(2 Ply)	4.4	AF-126	4	±45		2.009	2.011	0.043	160	2920	16.901
(2)	2	+	4.4	AF-126	4	±45		2.010	2.014	0.043	160	2640	15.272
	3	XP251S(2 Ply)	4.4	AF-126	4	±45		2.005	2.010	0.043	160	2620	15.195
4B-3	16		4.4	AF-126	4	±45		2.014	2.000(4)	0.043	-65	6775	39.117
(2)	17	BP907(2 Ply)	4.4	AF-126	4	±45		2.015	2.000(4)	0.043	-65	6300	36.355
	18	+	4.4	AF-126	4	±45		2.014	2.000(4)	0.043	-65	5600	32.333
	5	XP251S(2 Ply)	4.4	AF-126	4	±45		2.006	2.000(4)	0.043	-65*	5700	33.042
	7		4.4	AF-126	4	±45		2.002	2.000(4)	0.043	-65*	6100	35.430
	9		4.4	AF-126	4	±45		2.006	2.000(4)	0.043	-65*	6300	36.520
4A-2	1		4.4	AF-126	4	±45	A	1.992	2.010	0.031	75	3125	25.304
	2	BP907(2 Ply)	4.4	AF-126	4	±45	A	1.992	2.008	0.031	75	3250	26.316
	3	+	4.4	AF-126	4	±45	A	1.994	2.006	0.031	75	3200	25.886
	1	XP251S(2 Ply)	4.4	AF-126	4	±45	A	1.999	2.000(4)	0.031	75**	2625	21.181
	2		4.4	AF-126	4	±45	A	1.999	2.000(4)	0.031	75**	2700	21.786
	3		4.4	AF-126	4	±45	A	1.996	2.000(4)	0.031	75**	2750	22.222
4A-2	1	BP907(2 Ply)	4.4	AF-126	4	±45	A	1.987	2.006	0.031	160	1875	15.220
	2	+	4.4	AF-126	4	±45	A	1.996	2.004	0.031	160	1850	14.949
	3	XP251S(2 Ply)	4.4	AF-126	4	±45	A	1.992	2.009	0.031	160	1800	14.575
4A-2	1	BP907(2 Ply)	4.4	AF-126	4	±45	A	1.991	2.008	0.031	-65	6100	49.417
	2	+	4.4	AF-126	4	±45	A	1.993	2.009	0.031	-65	6000	48.559
	3	XP251S(2 Ply)	4.4	AF-126	4	±45	A	1.994	2.007	0.031	-65	6100	49.345
3C-2	1		4.4	AF-126	4	±45		2.025	2.000(4)	0.035	75	4350	30.688
(3)	2	BP907(2 Ply)	4.4	AF-126	4	±45		2.031	2.000(4)	0.035	75	4270	30.034
	3	+	4.4	AF-126	4	±45		2.004	2.000(4)	0.035	75	4250	30.297
	1	XP251S(2 Ply)	4.4	AF-126	4	±45		2.016	2.000(4)	0.035	75**	3500	24.802
	2		4.4	AF-126	4	±45		2.025	2.000(4)	0.035	75**	3450	24.339
	3		4.4	AF-126	4	±45		2.024	2.000(4)	0.035	75**	3750	26.468
3C-2	1	BP907(2 Ply)	4.4	AF-126	4	±45		2.022	2.000(4)	0.035	160	2775	19.606
(3)	2	+	4.4	AF-126	4	±45		2.008	2.000(4)	0.035	160	2700	19.209
	3	XP251S(2 Ply)	4.4	AF-126	4	±45		2.012	2.000(4)	0.035	160	2525	17.928

TABLE X . CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions: Width (In.)	Dimensions: (4) Length (In.)	Dimensions: Thick (In.)	Test Temp (°F)	Compressive Strength: Max Load (Lb)	Compressive Strength: Max Stress (ksi)
3C-2 (3)	1	BP907(2 Ply)	4.4	AF-126	4	±45		2.012	2.000(4)	0.035	-65	6000	42.602
	2	+	4.4	AF-126	4	∓45		2.018	2.000(4)	0.035	-65	5800	41.059
	3	XP251S(2 Ply)	4.4	AF-126	4	∓45		2.029	2.000(4)	0.035	-65	5800	40.836
3B-3 (2)	1		4.4	AF-126	4	±45		2.004	1.994	0.041	75	4100	24.951
	2		4.4	AF-126	4	∓45		2.013	1.989	0.041	75	4075	24.688
	3		4.4	AF-126	4	∓45		2.002	1.998	0.041	75	4030	24.549
	1	BP907(2 Ply)	4.4	AF-126	4	∓45		2.005	2.000(4)	0.041	75**	3500	21.288
	2	+	4.4	AF-126	4	∓45		2.005	2.000(4)	0.041	75**	3225	19.616
	3	XP251S(2 Ply)	4.4	AF-126	4	∓45		2.005	2.000(4)	0.041	75**	3600	21.896
	4		4.4	AF-126	4	∓45		2.004	2.000(4)	0.041	75*	4050	24.647
	6		4.4	AF-126	4	∓45		2.002	2.000(4)	0.041	75*	4075	24.823
	8		4.4	AF-126	4	∓45		2.004	2.000(4)	0.041	75*	4100	24.951
3B-3 (2)	1	BP907(2 Ply)	4.4	AF-126	4	±45		2.003	1.991	0.041	160	2700	16.439
	2	+	4.4	AF-126	4	∓45		2.006	2.000	0.041	160	2750	16.718
	3	XP251S(2 Ply)	4.4	AF-126	4	∓45		2.006	1.997	0.041	160	2800	17.022
3B-3 (2)	1		4.4	AF-126	4	±45		2.008	1.995	0.041	-65	6800	41.300
	2	BP907(2 Ply)	4.4	AF-126	4	∓45		2.002	1.998	0.041	-65	6800	41.423
	3	+	4.4	AF-126	4	∓45		2.004	1.992	0.041	-65	6750	41.078
	5	XP251S(2 Ply)	4.4	AF-126	4	∓45		2.005	2.000(4)	0.041	-65*	6300	38.319
	7		4.4	AF-126	4	∓45		2.004	2.000(4)	0.041	-65*	5900	35.906
	9		4.4	AF-126	4	∓45		2.004	2.000(4)	0.041	-65*	5650	34.384
3A-2	1		4.4	AF-126	4	±45	A	1.993	1.980	0.028	75	3725	33.378
	3	BP907(2 Ply)	4.4	AF-126	4	∓45	A	1.984	1.982	0.028	75	3700	33.303
	5	+	4.4	AF-126	4	∓45	A	1.986	1.990	0.028	75	3900	35.067
	12	XP251S(2 Ply)	4.4	AF-126	4	∓45	A	2.001	2.000(4)	0.028	75**	3525	31.459
	14		4.4	AF-126	4	∓45	A	1.998	2.000(4)	0.028	75**	3625	32.401
	6		4.4	AF-126	4	∓45	A	1.999	2.000(4)	0.028	75**	3650	32.607
3A-2	2	BP907(2 Ply)	4.4	AF-126	4	±45	A	1.989	1.983	0.028	160	2500	22.446
	4	+	4.4	AF-126	4	∓45	A	1.983	1.987	0.028	160	2500	22.514
	8	XP251S(2 Ply)	4.4	AF-126	4	∓45	A	1.992	1.986	0.028	160	2450	21.963
3A-2	7	BP907(2 Ply)	4.4	AF-126	4	±45	A	1.994	1.990	0.028	-65	5700	51.048
	8	+	4.4	AF-126	4	∓45	A	1.993	1.988	0.028	-65	5900	52.867
	9	XP251S(2 Ply)	4.4	AF-126	4	∓45	A	1.989	1.987	0.028	-65	6050	54.319
2C-2	1		4.4	FM-1000	4	0	B	1.997	2.000	0.024	75	4100	42.775
	2		4.4	FM-1000	4	0	B	1.991	2.000	0.024	75	4600	48.137
	3	XP251S	4.4	FM-1000	4	0	B	2.005	2.000	0.024	75	5000	51.953
	1		4.4	FM-1000	4	0	B	1.999	2.000	0.024	75**	3650	38.041
	2		4.4	FM-1000	4	0	B	1.996	2.000	0.024	75**	3525	36.795
	3		4.4	FM-1000	4	0	B	2.001	2.000	0.024	75**	3850	40.087

TABLE X . CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions: Width (In.)	Dimensions: (4) Length (In.)	Dimensions: Thick (In.)	Test Temp (°F)	Compressive Strength: Max Load (Lb)	Compressive Strength: Max Stress (ksi)
2C-2	1		4.4	FM-1000	4	0	B	1.994	2.000	0.024	160	3225	33.696
	2	XP251S	4.4	FM-1000	4	0	B	1.994	2.000	0.024	160	3260	34.061
	3		4.4	FM-1000	4	0	B	2.004	2.000	0.024	160	2800	29.109
2C-2	1		4.4	FM-1000	4	0	B	1.996	2.000	0.024	-65	5450	56.889
	2	XP251S	4.4	FM-1000	4	0	B	1.994	2.000	0.024	-65	4675	48.845
	3		4.4	FM-1000	4	0	B	2.004	2.000	0.024	-65	5200	54.060
2B-3	1		4.4	FM-1000	4	0	B	2.000	2.001	0.025	75	3950	39.500
	2		4.4	FM-1000	4	0	B	2.002	2.001	0.025	75	4050	40.460
	3		4.4	FM-1000	4	0	B	1.980	2.009	0.025	75	4375	44.192
	1		4.4	FM-1000	4	0	B	2.000	1.981	0.025	75**	4150	41.500
	2	XP251S	4.4	FM-1000	4	0	B	2.000	2.007	0.025	75**	3175	31.750
	3		4.4	FM-1000	4	0	B	2.000	1.982	0.025	75**	3250	32.500
	4		4.4	FM-1000	4	0	B	2.000	2.000	0.025	75*	4750	47.500
	6		4.4	FM-1000	4	0	B	2.000	2.000	0.025	75*	3950	39.500
	8		4.4	FM-1000	4	0	B	1.989	2.000	0.025	75*	4250	42.735
2B-3	1		4.4	FM-1000	4	0	B	1.998	1.997	0.025	160	3250	32.533
	2	XP251S	4.4	FM-1000	4	0	B	2.009	1.996	0.025	160	3225	32.106
	3		4.4	FM-1000	4	0	B	1.977	2.006	0.025	160	3550	35.913
2B-3	1		4.4	FM-1000	4	0	B	1.996	1.986	0.025	-65	4325	43.337
	2		4.4	FM-1000	4	0	B	1.968	2.034	0.025	-65	4925	50.051
	3	XP251S	4.4	FM-1000	4	0	B	1.944	2.000	0.025	-65	4700	48.354
	5		4.4	FM-1000	4	0	B	2.000	2.000	0.025	-65*	4075	40.750
	7		4.4	FM-1000	4	0	B	2.000	2.000	0.025	-65*	4500	45.000
	9		4.4	FM-1000	4	0	B	1.956	2.000	0.025	-65*	4650	47.546
2A-1	1		4.4	FM-1000	4	0	A	1.970	2.000(4)	0.025	75	5400	54.822
	2		4.4	FM-1000	4	0	A	1.976	2.000(4)	0.025	75	5200	52.632
	3	XP251S	4.4	FM-1000	4	0	A	1.978	2.000(4)	0.025	75	5100	51.567
	4		4.4	FM-1000	4	0	A	1.980	2.000(4)	0.025	75**	3550	35.859
	2		4.4	FM-1000	4	0	A	1.978	2.000(4)	0.025	75**	3500	35.389
	5		4.4	FM-1000	4	0	A	1.980	2.000(4)	0.025	75**	3650	36.869
2A-1	1		4.4	FM-1000	4	0	A	1.972	2.000(4)	0.025	160	3000	30.426
	2	XP251S	4.4	FM-1000	4	0	A	1.976	2.000(4)	0.025	160	2750	27.834
	3		4.4	FM-1000	4	0	A	1.978	2.000(4)	0.025	160	2550	25.784
2A-1	1		4.4	FM-1000	4	0	A	1.972	2.000(4)	0.025	-65	5250	53.245
	2	XP251S	4.4	FM-1000	4	0	A	1.978	2.000(4)	0.025	-65	5200	52.578
	4		4.4	FM-1000	4	0	A	1.981	2.000(4)	0.025	-65	5575	56.313

TABLE X . CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft3)	Material: Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions: Width (In.)	Dimensions: (4) Length (In.)	Dimensions: Thick (In.)	Test Temp (°F)	Compressive Strength: Max Load (Lb)	Compressive Strength: Max Stress (ksi)
1C-2	1		4.4	AF-126	4	0	B	2.006	2.010	0.026	75	4700	45.058
	2		4.4	AF-126	4	0	B	2.005	2.006	0.026	75	4675	44.840
	3	XP251S	4.4	AF-126	4	0	B	2.008	2.013	0.026	75	4900	46.930
	1		4.4	AF-126	4	0	B	2.003	2.006	0.026	75**	3625	34.806
	2		4.4	AF-126	4	0	B	2.009	2.007	0.026	75**	3900	37.335
	3		4.4	AF-126	4	0	B	1.997	2.006	0.026	75**	4300	41.410
1C-2	1		4.4	AF-126	4	0	B	2.010	2.016	0.026	[illegible]	3875	37.074
	2	XP251S	4.4	AF-126	4	0	B	2.008	2.010	0.026	160	3600	34.479
	3		4.4	AF-126	4	0	B	2.016	2.008	0.026	160	4000	38.157
1C-2	1		4.4	AF-126	4	0	B	2.014	2.006	0.026	-65	5900	56.341
	2	XP251S	4.4	AF-126	4	0	B	2.010	2.004	0.026	-65	5500	52.622
	3		4.4	AF-126	4	0	B	2.010	1.997	0.026	-65	5300	50.708
1B-3	1		4.4	AF-126	4	0	B	2.007	2.014	0.024	75	5150	53.462
	3		4.4	AF-126	4	0	B	2.005	2.015	0.024	75	5100	52.993
	5		4.4	AF-126	4	0	B	2.010	2.010	0.024	75	4900	50.788
	2		4.4	AF-126	4	0	B	2.012	2.010	0.024	75**	3725	38.573
	3	XP251S	4.4	AF-126	4	0	B	2.011	2.012	0.024	75**	3750	38.852
	4		4.4	AF-126	4	0	B	2.011	2.011	0.024	75**	3200	33.154
	2		4.4	AF-126	4	0	B	2.008	2.010	0.024	75*	4300	44.615
	2		4.4	AF-126	4	0	B	2.004	2.013	0.024	75*	4725	49.122
	4		4.4	AF-126	4	0	B	2.008	2.012	0.024	75*	4450	46.171
1B-3	2		4.4	AF-126	4	0	B	1.998	2.012	0.024	160	3550	37.018
	3	XP251S	4.4	AF-126	4	0	B	2.016	2.024	0.024	160	3700	38.239
	5		4.4	AF-126	4	0	B	1.998	2.011	0.024	160	3300	34.411
1B-3	3		4.4	AF-126	4	0	B	2.006	2.010	0.024	-65	6300	65.434
	4		4.4	AF-126	4	0	B	2.011	2.011	0.024	-65	6075	62.940
	5	XP251S	4.4	AF-126	4	0	B	2.007	2.011	0.024	-65	6000	62.286
	2		4.4	AF-126	4	0	B	2.004	2.000	0.024	-65*	5600	58.218
	4		4.4	AF-126	4	0	B	2.016	2.000	0.024	-65*	5050	52.191
	5		4.4	AF-126	4	0	B	2.008	2.000	0.024	-65*	5500	57.066
1A-2	1		4.4	AF-126	4	0	A	2.014	2.007	0.026	75	4375	41.778
	2		4.4	AF-126	4	0	A	2.015	2.005	0.026	75	4500	42.947
	3	XP251S	4.4	AF-126	4	0	A	2.010	2.010	0.026	75	5000	47.838
	1		4.4	AF-126	4	0	A	2.009	2.001	0.026	75**	3875	37.096
	2		4.4	AF-126	4	0	A	2.002	2.002	0.026	75**	4750	45.629
	3		4.4	AF-126	4	0	A	2.001	2.001	0.026	75**	3575	34.358

TABLE X . CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (Lb/Ft^3)	Material: Adhesive	(5) Number of Plies	(6) Ply Angle (Degrees)	(3) Cure	Dimensions: Width (In.)	Dimensions: (4) Length (In.)	Dimensions: Thick (In.)	Test Temp (°F)	Compressive Strength: Max Load (Lb)	Compressive Strength: Max Stress (ksi)
1A-2	1		4.4	AF-126	4	0	A	2.012	2.006	0.026	160	3425	32.738
	2	XP251S	4.4	AF-126	4	0	A	2.009	2.012	0.026	160	3250	31.112
	3		4.4	AF-126	4	0	A	2.016	2.008	0.026	160	3190	30.430
1A-2	1		4.4	AF-126	4	0	A	2.014	2.000	0.026	-65	5500	52.521
	2	XP251S	4.4	AF-126	4	0	A	2.012	2.002	0.026	-65	4625	44.208
	3		4.4	AF-126	4	0	A	2.014	2.004	0.026	-65	5400	51.566

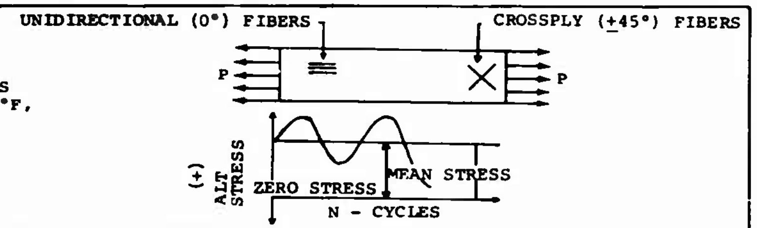


TABLE XI. TENSION FATIGUE PROPERTIES FOR EPOXY RESIN LAMINATES REINFORCED WITH (1) S-GLASS FIBERS AND (2) 143S-STYLE FABRIC AND TESTED AT -65°F, 75°F, AND 160°F.

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Test Temp (°F)	Stress Ratio	Fatigue Strength: Runouts Stress-Ksi Mean	Runouts Stress-Ksi Alt	Runouts Cycles (x 10⁶)	Failures Stress-Ksi Mean	Failures Stress-Ksi Alt	Failures Cycles (x 10⁶)
L-1	2		7	0	A	-65	0.10				39.7	±32.5	0.062
	4		7	0	A	-65	0.10				36.7	±30.0	0.583
	6		7	0	A	-65	0.10				33.5	±27.5	0.676
	8		7	0	A	-65	0.10				30.6	±25.0	4.657
	10		7	0	A	-65	0.10				29.4	±24.0	0.489
	12		7	0	A	-65	0.10				27.5	±22.5	5.707
	14	1002S	7	0	A	160	0.10				33.5	±27.5	1.314
	16		7	0	A	160	0.10	30.6	±25.0	10.250	—	—	—
	18		7	0	A	160	0.10				39.7	±32.5	0.612
	20		7	0	A	160	0.10				36.7	±30.0	1.273
	22		7	0	A	160	0.10				35.4	±29.0	2.019
	24		7	0	A	160	0.10				31.8	±26.0	1.832
L-1B	3		7	0	A+B	75	0.05				33.2	±30.0	6.937
	5		7	0	A+B	-65	0.10				39.7	±32.5	0.055
	7		7	0	A+B	-65	0.10				36.7	±30.0	0.703
	9		7	0	A+B	-65	0.10				33.5	±27.5	1.183
	11		7	0	A+B	-65	0.10				30.6	±25.0	0.200
	13		7	0	A+B	-65	0.10				30.6	±25.0	0.760
	15	1002S	7	0	A+B	-65	0.10				24.4	±20.0	2.711
	17		7	0	A+B	160	0.10				36.7	±30.0	4.238
	19		7	0	A+B	160	0.10				39.7	±32.5	1.189
	21		7	0	A+B	160	0.10				42.7	±35.0	0.376
	23		7	0	A+B	160	0.10	33.5	±27.5	10.209	—	—	—
	25		7	0	A+B	160	0.10				45.8	±37.5	0.249
	26		7	0	A+B	160	0.10				47.0	±38.5	0.135

(1) - Scotchply XP251S and 1002S nonwoven organic prepreg.

(2) - Woven organic prepreg

(3) - Orientation of fibers relative to longitudinal load axis.

Cure

A - 1 hour at 280-290°F + 1 hour at 330-340°F at 50 psig, vented

B - Cure A + 16 hours postcure at 280-290°F, under vacuum pressure.

TABLE XI. CONTINUED

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Test Temp (°F)	Stress Ratio	Fatigue Strength: Runouts Stress-Ksi Mean	Runouts Stress-Ksi Alt	Runouts Cycles (x 10^6)	Failures Stress-Ksi Mean	Failures Stress-Ksi Alt	Failures Cycles (x 10^6)
L-3	1		6	±45	A	-65	0.10				6.1	±5.0	0.042
	2		6	±45	A	-65	0.10	4.89	±4.0	10.012	—	—	—
	4		6	±45	A	-65	0.10				5.5	±4.5	0.361
	6		6	±45	A	-65	0.10				5.3	±4.25	0.518
	8		6	±45	A	-65	0.10				5.0	±4.1	4.003
	9	1002S	6	±45	A	-65	0.10				5.8	±4.75	3.149
	10		6	±45	A	160	0.10				5.5	±4.5	0.003
	12		6	±45	A	160	0.10				4.89	±4.0	0.003
	14		6	±45	A	160	0.10				4.58	±3.75	0.010
	15		6	±45	A	160	0.10				3.67	±3.0	0.008
	16		6	±45	A	160	0.10	2.45	±2.0	10.188	—	—	—
	18		6	±45	A	160	0.10				3.05	±2.5	5.468
L-4	2		6	±45	B	75	0.10				4.89	±4.0	0.962
	4		6	±45	B	-65	0.10	4.89	±4.0	10.067	—	—	—
	6		6	±45	B	-65	0.10				6.1	±5.0	0.737
	8		6	±45	B	-65	0.10				7.35	±6.0	0.076
	10		6	±45	B	-65	0.10				6.75	±5.5	0.497
	12		6	±45	B	-65	0.10				7.65	±6.25	0
	14	1002S	6	±45	B	-65	0.10				7.03	±5.75	0
	16		6	±45	B	160	0.10				4.89	±4.0	0.010
	18		6	±45	B	160	0.10				4.58	±3.75	0.010
	20		6	±45	B	160	0.10				3.05	±2.50	0.150
	24		6	±45	B	160	0.10	3.67	±3.0	10.081	—	—	—
	28		6	±45	B	160	0.10	2.5	±2.0	10.023	—	—	—
	30		6	±45	B	160	0.10				2.77	±2.25	8.302
L-5B	2		7	0	A+B	75	0.05	28.7	±26.0	10.005	32.3	±30.0	0.636 (Retest)
	3		7	0	A+B	-65	0.10				39.7	±32.5	0
	6		7	0	A+B	-65	0.10				33.5	±27.5	0.585
	7		7	0	A+B	-65	0.10				30.6	±25.0	0.205
	15		7	0	A+B	-65	0.10	27.5	±22.5	10.000	—	—	—
	16	XP251S	7	0	A+B	-65	0.10				30.6	±25.0	0.713
	17		7	0	A+B	-65	0.10				28.1	±23.0	0.045
	19		7	0	A+B	160	0.10				30.6	±25.0	1.731
	20		7	0	A+B	160	0.10				33.7	±27.5	3.887
	21		7	0	A+B	160	0.10				34.8	±28.5	1.461
	22		7	0	A+B	160	0.10	31.8	±26.0	10.029	—	—	—
	23		7	0	A+B	160	0.10				35.5	±29.0	4.739
	24		7	0	A+B	160	0.10				36.7	±30.0	1.899

TABLE XI. CONTINUED

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Test Temp (°F)	Stress Ratio	Fatigue Strength: Runouts Stress-Ksi Mean	Runouts Stress-Ksi Alt	Runouts Cycles (x 10^6)	Failures Stress-Ksi Mean	Failures Stress-Ksi Alt	Failures Cycles (x 10^6)
L-25	1		7	0	A+B	-65	0.10				39.7	±32.5	0.050
	2		7	0	A+B	-65	0.10				36.7	±30.0	0.183
	3		7	0	A+B	-65	0.10				33.6	±27.5	0.189
	4		7	0	A+B	-65	0.10				30.6	±25.0	0.268
	5		7	0	A+B	-65	0.10				24.5	±20.0	1.618
	6	XP251S	7	0	A+B	-65	0.10	18.3	±15.0	10.259	—	—	—
	7		7	0	A+B	160	0.10				30.6	±25.0	0.408
	10		7	0	A+B	160	0.10				33.6	±27.5	0.073
	13		7	0	A+B	160	0.10				36.7	±30.0	0.126
	14		7	0	A+B	160	0.10				27.5	±22.5	0.465
	15		7	0	A+B	160	0.10				26.3	±21.5	0.635
	16		7	0	A+B	160	0.10				22.0	±18.0	1.398
L-7	1		6	±45	A	-65	0.10				6.1	±5.0	0.080
	2		6	±45	A	-65	0.10				6.75	±5.5	0.025
	3		6	±45	A	-65	0.10				5.5	±4.5	3.490
	5		6	±45	A	-65	0.10				5.2	±4.25	2.056
	7		6	±45	A	-65	0.10				5.8	±4.75	1.100
	8	XP251S	6	±45	A	-65	0.10				6.43	±5.25	0.504
	9		6	±45	A	160	0.10				6.11	±5.0	0.002
	11		6	±45	A	160	0.10				3.67	±3.0	0.967
	13		6	±45	A	160	0.10	3.05	±2.5	10.020	—	—	—
	15		6	±45	A	160	0.10				4.28	±3.5	0.426
	16		6	±45	A	160	0.10				3.42	±2.8	0.992
	17		6	±45	A	160	0.10				3.97	±3.25	0.056
L-8	2		6	±45	B	75	0.10				4.89	±4.0	5.069
	4		6	±45	B	-65	0.10				5.5	±4.5	2.231
	6		6	±45	B	-65	0.10				6.1	±5.0	0.211
	8		6	±45	B	-65	0.10				5.2	±4.25	1.348
	12		6	±45	B	-65	0.10	5.0	±4.[illegible]5	10.003	—	—	—
	14		6	±45	B	-65	0.10				5.8	±4.75	1.708
	16	XP251S	6	±45	B	-65	0.10				6.43	±5.25	1.004
	18		6	±45	B	160	0.10	3.67	±3.0	10.151	—	—	—
	20		6	±45	B	160	0.10				5.55	±4.5	0.008
	22		6	±45	B	160	0.10				4.89	±4.0	0.008
	24		6	±45	B	160	0.10				4.58	±3.75	0.015
	26		6	±45	B	160	0.10				4.28	±3.5	0.090
	28		6	±45	B	160	0.10				3.97	±3.25	1.003

TABLE XI. CONTINUED

Panel Number	Specimen Number	Material	Number of Plies	(3) Ply Angle (Degrees)	Cure	Test Temp (°F)	Stress Ratio	Fatigue Strength: Runouts Stress-Ksi Mean	Runouts Stress-Ksi Alt	Runouts Cycles (x 10^6)	Failures Stress-Ksi Mean	Failures Stress-Ksi Alt	Failures Cycles (x 10^6)
L-9B	1		7	0	A+B	-65	0.05				14.4	±13.0	0.718
	2		7	0	A+B	-65	0.10				12.2	±10.0	0.800
	3		7	0	A+B	-65	0.10				15.9	±13.0	0.422
	4	BP907/ 1437	7	0	A+B	160	0.10	12.2	±10.0	10.115	—	—	—
	5		7	0	A+B	160	0.10				15.9	±13.0	0.646
	6		7	0	A+B	160	0.10				18.3	±15.0	0.127
	7		7	0	A+B	160	0.10				19.55	±16.0	0.065
	8		7	0	A+B	160	0.10				17.1	±14.0	0.232
	9		7	0	A+B	160	0.10				14.7	±12.0	3.233
L-10B	25		7	0	B	75	0.05				14.4	±13.0	0.840
	26	BP907/ 1437	7	0	B	-65	0.10				18.3	±15.0	0.323
	27		7	0	B	-65	0.05				14.4	±13.0	0.538
	28		7	0	B	-65	0.10				12.2	±10.0	1.759
L-10	8		7	0	A	-65	0.05				14.4	±13.0	0.763
	10		7	0	A	-65	0.10				18.3	±15.0	0.192
	15		7	0	A	-65	0.10				12.2	±10.0	6.528
	16		7	0	A	-65	0.10	11.0	±9.0	10.002	—	—	—
	17		7	0	A	-65	0.10				15.9	±13.0	0.989
	18	BP907/ 1437	7	0	A	-65	0.10				13.4	±11.0	1.885
	19		7	0	A	160	0.10	12.0	±10.0	10.004	—	—	—
	20		7	0	A	160	0.10				15.9	±13.0	1.415
	21		7	0	A	160	0.10				18.3	±15.0	0.028
	22		7	0	A	160	0.10				18.3	±15.0	0.026
	23		7	0	A	160	0.10				17.1	±14.0	0.324
	24		7	0	A	160	0.10				14.7	±12.0	2.783

Summary of Test Data from Test Panel Numbers 1 & 1B, Fabricated of Unidirectional 1002S

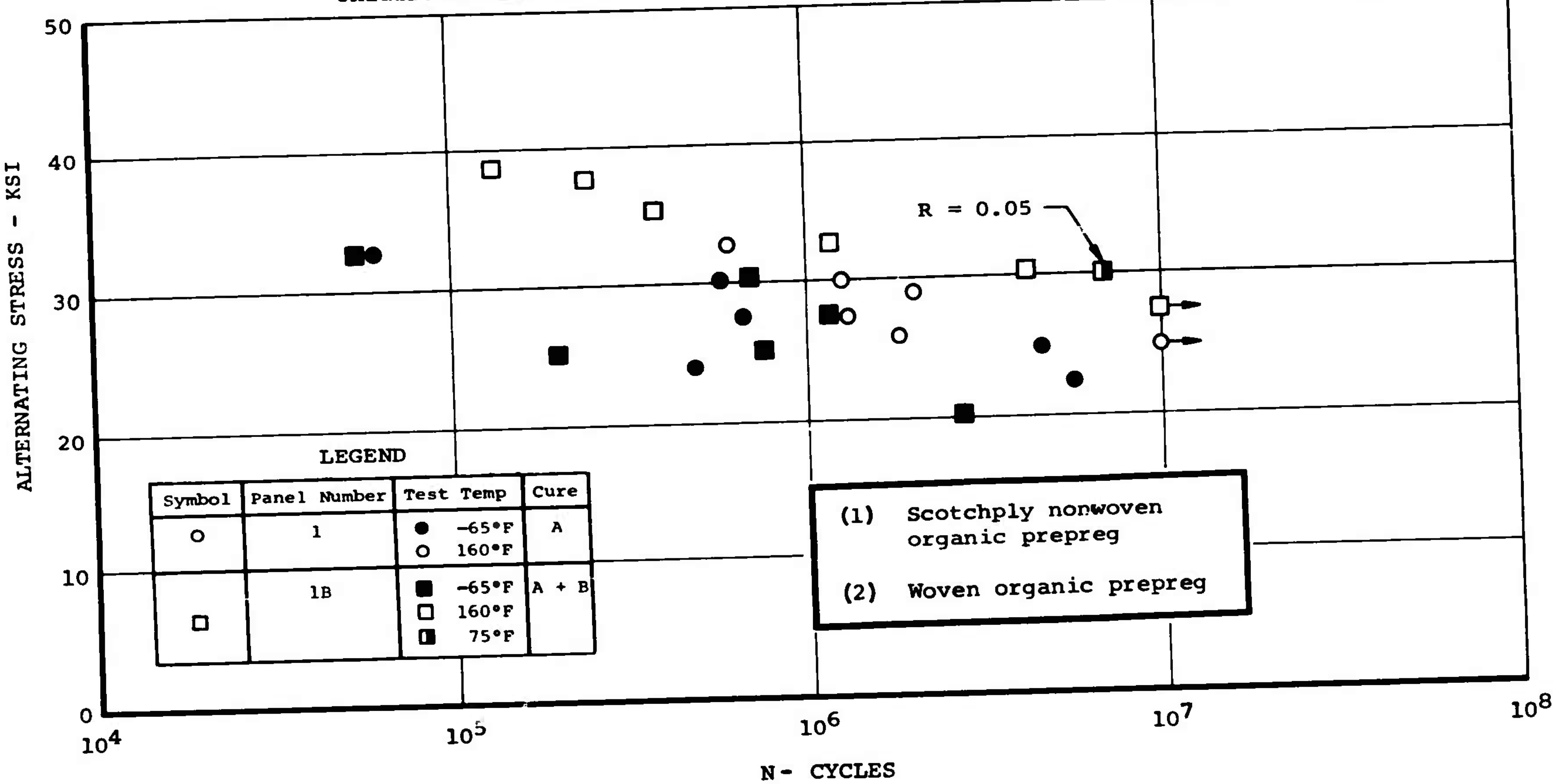


Figure 66. S-N Curve for Epoxy Resin Laminates Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F, 75°F, and 160°F. Stress Ratio (R) = 0.10 Except as Noted at Data Points.

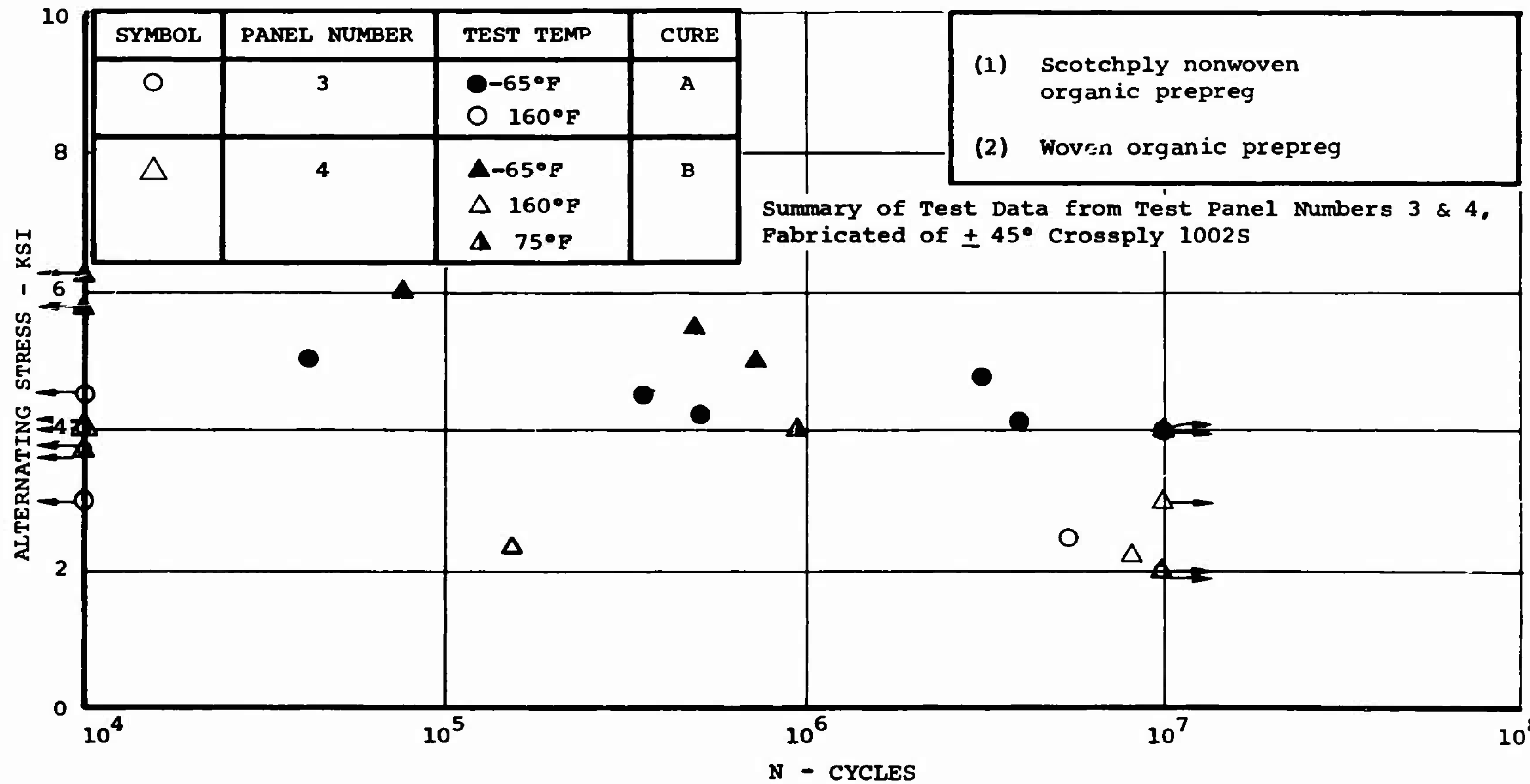


Figure 67. S-N Curve for Epoxy Resin Laminates Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F, 75°F, and 160°F. Stress Ratio (R) = 0.10 Except as Noted at Data Points.

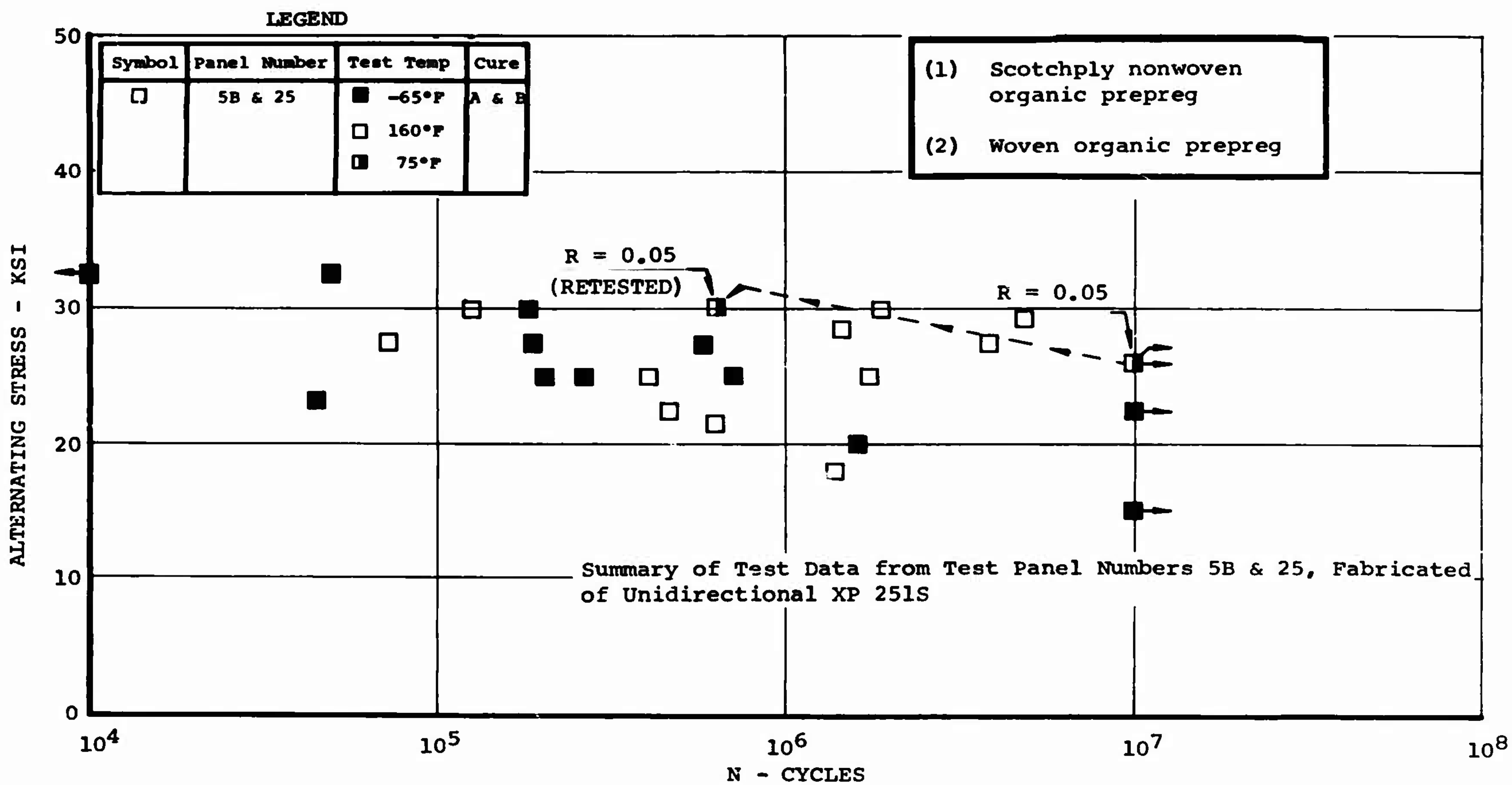


Figure 68. S-N Curve for Epoxy Resin Laminates Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F, 75°F, and 160°F. Stress Ratio (R) = 0.10 Except as Noted at Data Points.

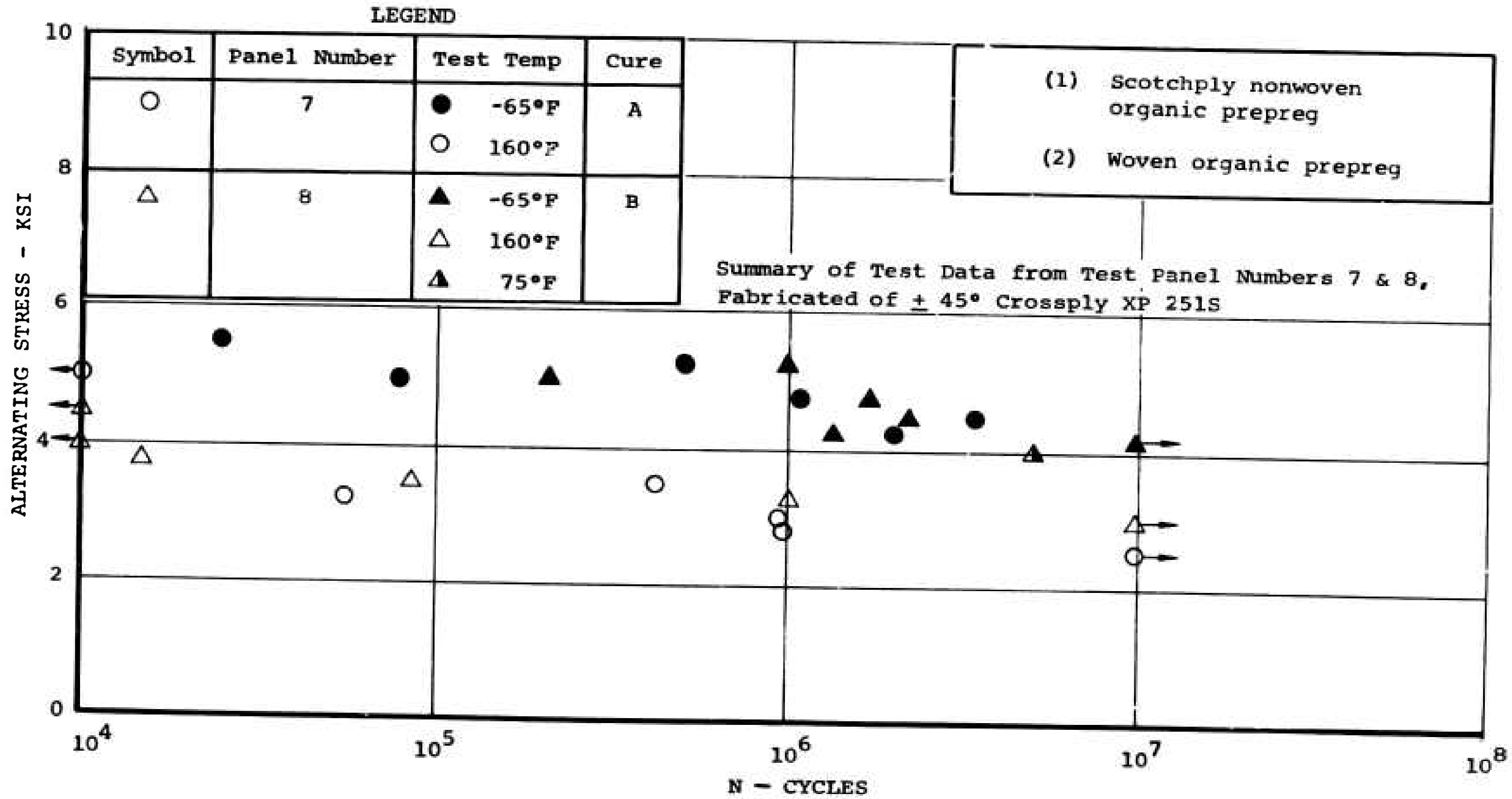


Figure 69. S-N Curve for Epoxy Resin Laminates Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F, 75°F, and 160°F. Stress Ratio (R) = 0.10 Except as Noted at Data Points.

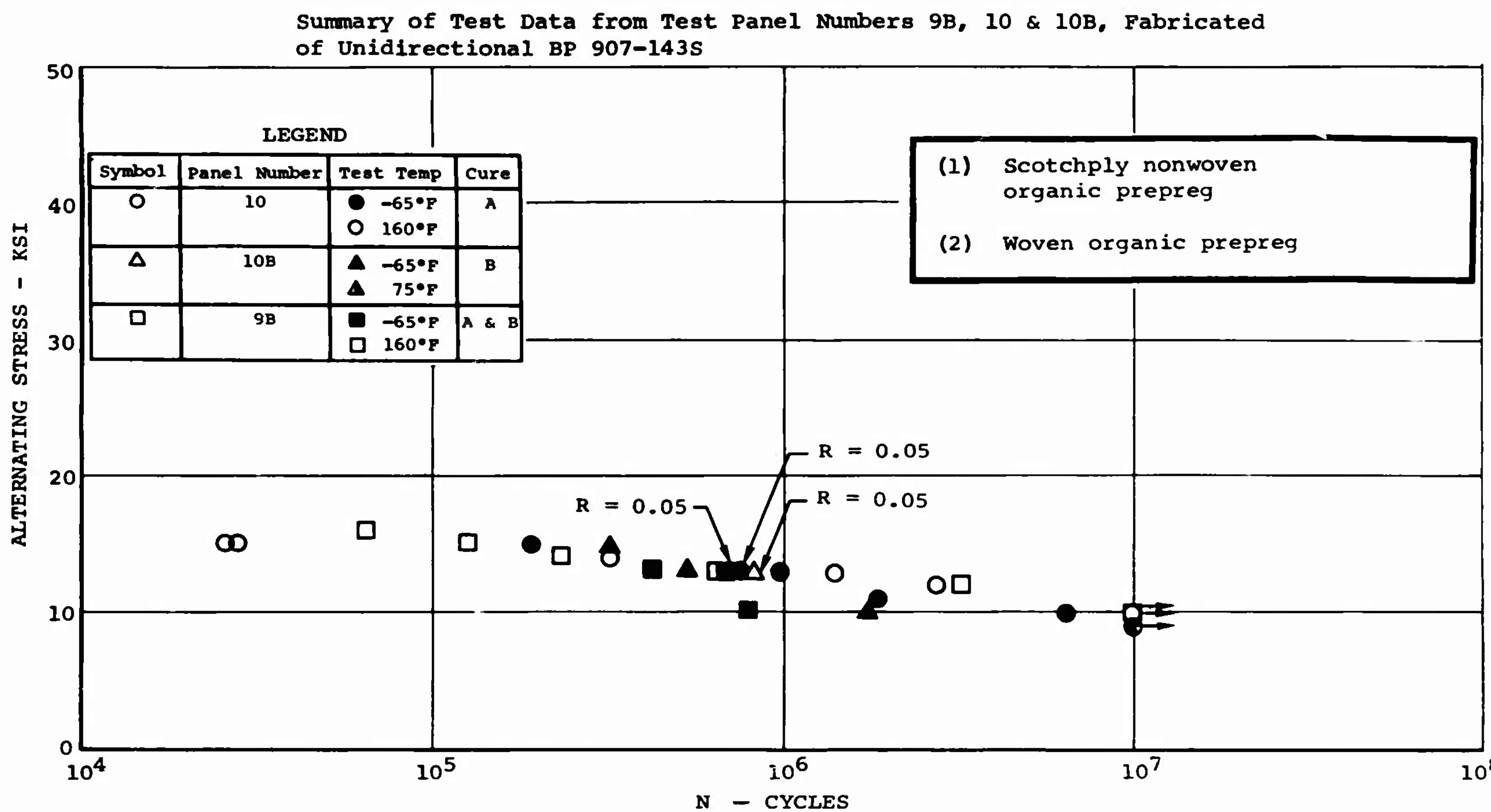


Figure 70. S-N Curve for Epoxy Resin Laminates Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F, 75°F, and 160°F. Stress Ratio (R) = 0.10 Except as Noted at Data Points.

TABLE XII. FATIGUE PROPERTIES FOR SANDWICH BEAMS CONSTRUCTED OF ALUMINUM CORES AND LAMINATED EPOXY RESIN PANELS REINFORCED WITH (1) S-GLASS FIBERS AND (2) 143S-STYLE FABRIC AND TESTED AT -65°F AND 75°F.

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft^3)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Flexure Strength: Cycles to Failure (x 10^6)	Type of Failure
1-A1	1	XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	75	2115 ± 1730	36.228	29.633	0.000	c at grips
	3	XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	75	1410 ± 1155	24.077	19.723	1.643	d at t.a.
	5	XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	75	1410 ± 1155	24.102	19.743	2.661	d at t.a.
	7	XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	-65	1410 ± 1155	24.052	19.703	3.304	d in tension
	9	XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	-65	1410 ± 1155	24.176	19.804	R.O.	g
		XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	-65	1630 ± 1328	27.949	22.770	0.369	c at t.a.
	12	XP251S	4.4	AF126	4	0	A	2.000	0.030	0.0600	-65	1410 ± 1155	24.227	19.845	1.092	d at t.a.
1-A2	3	XP251S	4.4	AF126	4	0	A	2.012	0.030	0.0603	75**	1588 ± 1300	25.796	21.118	0.070	a,d at t.a.
	5	XP251S	4.4	AF126	4	0	A	2.019	0.030	0.0606	75**	1410 ± 1155	22.845	18.714	1.138	a,d at t.a.
	7	XP251S	4.4	AF126	4	0	A	2.022	0.030	0.0606	75**	1468 ± 1200	23.749	19.414	0.133	c in tension

Cure

A - 1 hour at 330-340°F at 30 psig

B - 2 hours at 330-340°F at 30 psig plus 16 hours postcure at 280°F, under vacuum pressure

Specimen Conditioning

* Specimen artificially weathered for 300 hours and tested within 30 days at specified temperature

** Specimen exposed to 120°F in condensing humidity chamber (100 percent humidity) for 30 days and tested within 30 minutes at specified temperature

*** Artificially weathered plus condensing humidity(**)

(1) Scotchply XP251S and 1002S nonwoven organic prepreg

(2) BP907-143S woven organic prepreg

(3) Number of plys pertains to either tension or compression face of beam

(4) 143S Fabric and unidirectional material laid up relative to core ribbon direction

Failure Type

a) Amplitude failure
b) Adhesive bond failure
c) Catastrophic failure
d) Fiber delamination failure
e) Facing failure
f) Invalid test
g) No failure

(#) Specimens exposed to actual climatic conditions encountered in the Mid-Atlantic region of the United States for a period of 15 months

TABLE XII. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft^3)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area ($In.^2$)	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Cycles to Failure ($x 10^6$)	Type of Failure
1-B1	1	XP251S	4.4	AF126	4	0	B	1.980	0.030	0.0594	-65	1410 ± 1155	23.717	19.428	7.715	c at t.a.
	5	XP251S	4.4	AF126	4	0	B	2.016	0.030	0.0605	-65	1410 ± 1155	23.741	19.448	4.262	b
	7	XP251S	4.4	AF126	4	0	B	2.005	0.030	0.0601	75	1410 ± 1155	23.995	19.656	1.292	c at t.a.
	9	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	23.995	19.656	1.831	d at t.a.
	11	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75**	1588 ± 1300	28.459	23.297	3.224	a,d at t.a.
1-B2	3	XP251S	4.4	AF126	4	0	B	1.970	0.030	0.0591	-65	1410 ± 1155	24.298	19.903	0.853	c in tension
	5	XP251S	4.4	AF126	4	0	B	1.978	0.030	0.0593	75	1410 ± 1155	24.197	19.821	4.431	a,d at t.a.
	7	XP251S	4.4	AF126	4	0	B	1.975	0.030	0.0592	75**	1410 ± 1155	24.160	19.790	5.147	c at t.a.
	9	XP251S	4.4	AF126	4	0	B	1.972	0.030	0.0592	75**	1410 ± 1155	24.298	19.903	4.213	a,d at t.a.
1-B3	6	XP251S	4.4	AF126	4	0	B	1.970	0.030	0.0591	75***	1100 ± 900	18.303	14.975	1.360	c at t.a.
	8	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	-65*	1410 ± 1155	23.125	18.940	0.231	a,d at t.a.
	10	XP251S	4.4	AF126	4	0	B	2.010	0.030	0.0603	-65*	1100 ± 900	17.900	14.630	1.909	a,d at t.a.
	12	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75***	1130 ± 925	18.500	15.144	2.651	a,d at t.a.
1-B4	2	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	-65*	1410 ± 1155	23.075	18.890	0.310	a,d at t.a.
	4	XP251S	4.4	AF126	4	0	B	2.010	0.030	0.0603	75***	1160 ± 950	18.893	15.472	1.045	d at t.a.
	6	XP251S	4.4	AF126	4	0	B	2.030	0.030	0.0609	75*	1410 ± 1155	22.766	18.648	0.080	e
	8	XP251S	4.4	AF126	4	0	B	2.050	0.030	0.0615	75*	1220 ± 1000	19.487	15.973	0.080	e
	10	XP251S	4.4	AF126	4	0	B	2.050	0.030	0.0615	75*	1100 ± 900	17.553	14.361	1.695	e
1-C1	2	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	-65	1410 ± 1155	23.017	18.854	0.173	d at t.a.
	4	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	-65	1410 ± 1155	23.017	18.854	0.229	d at t.a.
	6	XP251S	4.4	AF126	4	0	B	2.010	0.030	0.0603	75	1410 ± 1155	22.949	18.799	0.080	d at t.a.
	8	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	22.927	18.780	0.076	c at t.a.
	10	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.017	18.854	0.218	c in tension
	12	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.084	18.910	0.387	c in compression
1-C2	2	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	-65	1410 ± 1155	22.727	18.617	0.136	d at t.a.
	5	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	23.062	18.891	0.191	c at t.a.
	8	XP251S	4.4	AF126	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.017	18.854	0.097	c in tension
2-A1	6	XP251S	4.4	FM1000	4	0	A	1.990	0.030	0.0597	75**	1100 ± 900	18.100	14.809	3.227	a,d at t.a.
	9	XP251S	4.4	FM1000	4	0	A	1.985	0.030	0.0595	75**	1410 ± 1155	23.329	19.110	1.058	c in tension
	13	XP251S	4.4	FM1000	4	0	A	1.987	0.030	0.0596	75**	1410 ± 1155	23.260	19.053	0.744	c in tension
2-A2	1	XP251S	4.4	FM1000	4	0	A	2.000	0.030	0.0600	75	1410 ± 1155	24.053	19.703	4.151	a,d at t.a.
	2	XP251S	4.4	FM1000	4	0	A	2.000	0.030	0.0600	75	1410 ± 1155	24.152	19.784	1.369	c at t.a.
	3	XP251S	4.4	FM1000	4	0	A	2.000	0.030	0.0600	75	1410 ± 1155	24.127	19.764	3.114	c at t.a.
	5	XP251S	4.4	FM1000	4	0	A	2.000	0.030	0.0600	-65	1410 ± 1155	24.102	19.743	R.O.	g
	6	XP251S	4.4	FM1000	4	0	A	2.000	0.030	0.0600	-65	1410 ± 1155	24.152	19.784	3.942	f
	7	XP251S	4.4	FM1000	4	0	A	2.000	0.030	0.0600	-65	1558 ± 1300	26.660	22.245	2.146	c,d at t.a.

TABLE XII. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft^3)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Cycles to Failure (x 10^6)	Type of Failure
2-B1	1	XP251S	4.4	FM1000	4	0	B	2.025	0.030	0.0608	-65	1410 ± 1155	23.590	19.324	R.O.	g
	3	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	-65	1588 ± 1300	27.034	22.131	1.594	d on tension
	5	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	24.004	19.663	3.113	c,d at t.a.
	7	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	23.979	19.643	2.347	a,d at t.a.
	9	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	24.127	19.764	0.068	c in compression
	12	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.406	19.173	5.506	d at t.a.
2-B2	1	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	-65	1588 ± 1300	26.546	21.732	9.251	d at t.a.
	3	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	23.430	19.192	7.779	a,d at t.a.
	5	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.476	19.231	10.076	g
2-B3	1	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.107	18.928	2.000	e
	3	XP251S	4.4	FM1000	4	0	B	2.010	0.030	0.0603	75***	1410 ± 1155	22.972	18.817	2.278	c in tension
	6	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75***	1410 ± 1155	23.176	18.984	0.062	c in compression
	9	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75*	1410 ± 1155	23.107	18.928	1.481	e
2-B4 (1)	1	XP251S	4.4	FM1000	4	0		2.000	0.030	0.0600	75*	1588 ± 1300	25.923	21.221	0.370	e
	4	XP251S	4.4	FM1000	4	0		2.000	0.030	0.0600	-65*	1588 ± 1300	25.923	21.221	1.718	a,d at t.a.
	7	XP251S	4.4	FM1000	4	0		2.000	0.030	0.0600	75***	1410 ± 1155	22.994	18.836	2.103	e
	10	XP251S	4.4	FM1000	4	0		2.000	0.030	0.0600	-65*	1835 ± 1500	29.954	24.486	0.237	a,d at t.a.
	12	XP251S	4.4	FM1000	4	0		2.000	0.030	0.0600	-65*	1530 ± 1250	24.975	20.409	4.960	a,d at t.a.
2-C1	1	XP251S	4.4	FM1000	4	0	B	2.015	0.030	0.0605	-65	1410 ± 1155	23.325	19.107	1.835	a
	3	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	-65	1410 ± 1155	23.360	19.135	R.O.	g
	5	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	-65	1410 ± 1155	23.406	19.173	R.O.	g
	7	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75	1410 ± 1155	23.406	19.173	3.303	c at t.a.
	9	XP251S	4.4	FM1000	4	0	B	1.992	0.030	0.0598	75	1410 ± 1155	23.500	19.250	2.813	a
	12	XP251S	4.4	FM1000	4	0	B	2.027	0.030	0.0608	75	1410 ± 1155	23.163	18.975	2.870	d at t.a.
2-C2	4	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.062	18.891	0.024	c in compression
	8	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.107	18.928	0.004	c in compression
	12	XP251S	4.4	FM1000	4	0	B	2.000	0.030	0.0600	75**	1410 ± 1155	23.062	18.891	0.464	c in compression
3-A1	3	BP907 (2 Ply) + XP251S (2 Ply)	4.4	AF126	4	±45	A	2.000	0.038	0.0760	-65	390 ± 319	5.061	4.139	R.O.	g
	5		4.4	AF126	4	±45	A	2.000	0.038	0.0760	-65	490 ± 400	6.358	5.190	0.038	a at t.a.
	7		4.4	AF126	4	±45	A	2.000	0.038	0.0760	75	390 ± 319	5.061	4.139	0.685	a
	9		4.4	AF126	4	±45	A	2.000	0.038	0.0760	75	390 ± 319	5.066	4.144	2.960	a
	11		4.4	AF126	4	±45	A	2.000	0.038	0.0760	75**	390 ± 319	5.066	4.144	0.015	a
	13		4.4	AF126	4	±45	A	2.000	0.038	0.0760	75**	390 ± 319	5.036	4.119	0.012	a
3-A2	3	BP907 (2Ply) + XP251S (2 Ply)	4.4	AF126	4	±45	A	1.981	0.038	0.0753	-65	427 ± 350	5.600	4.590	0.053	a at t.a.
	7		4.4	AF126	4	±45	A	1.994	0.038	0.0758	75	390 ± 319	5.081	4.156	1.135	a
	9		4.4	AF126	4	±45	A	1.991	0.038	0.0757	75**	367 ± 300	4.794	3.919	0.073	a

TABLE XII. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft^3)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Flexure Strength: Cycles to Failure (x 10^6)	Type of Failure
3-B1	3		4.4	AF126	4	±45		2.000	0.038	0.0760	-65	490 ± 400	6.229	5.085	0.191	a
(2)	5	BP907(2Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	-65	427 ± 350	5.423	4.445	0.135	a,d at t.a.
	7		4.4	AF126	4	±45		2.000	0.038	0.0760	75	270 ± 221	3.433	2.816	R.O.	g
	9	+	4.4	AF126	4	±45		2.000	0.038	0.0760	75	390 ± 319	4.963	4.059	3.483	a
	11	XP251S	4.4	AF126	4	±45		2.000	0.038	0.0760	75**	390 ± 319	4.958	4.055	0.673	a,d
	13	(2 Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	75**	390 ± 319	4.973	4.067	0.281	a.d
3-B2	5	BP907(2Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	-65	427 ± 350	5.439	4.458	1.273	a,d at t.a.
(2)	7	+	4.4	AF126	4	±45		2.000	0.038	0.0760	75	390 ± 319	4.963	4.059	2.585	a
	9	XP251S	4.4	AF126	4	±45		2.000	0.038	0.0760	75**	427 ± 350	5.439	4.458	0.031	d
		(2 Ply)														
3-B3	1	BP907(2Ply)	4.4	AF126	4	±45		1.940	0.038	0.0737	75*	390 ± 319	5.082	4.157	2.501	a at t.a.
(2)	3	+	4.4	AF126	4	±45		1.960	0.038	0.0745	75***	367 ± 300	4.725	3.862	1.236	a
	5	XP251S	4.4	AF126	4	±45		1.960	0.038	0.0745	75*	490 ± 400	6.278	5.124	0.106	a at t.a.
	7	(2Ply)	4.4	AF126	4	±45		1.960	0.038	0.0745	75*	427 ± 350	5.497	4.506	0.552	a at t.a.
3-B4	1		4.4	AF126	4	±45		2.000	0.038	0.0760	75***	390 ± 319	4.930	4.032	0.003	a
(3)	4	BP907(2Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	-65*	427 ± 350	5.385	4.410	R.O.	g
	7	+	4.4	AF126	4	±45		2.000	0.038	0.0760	75***	390 ± 319	4.920	4.025	2.577	a
	10	XP251S	4.4	AF126	4	±45		2.000	0.038	0.0760	-65*	490 ± 400	6.170	5.036	R.O.	g
	12	(2 Ply)	4.4	AF126	4	±45		2.010	0.038	0.0764	-65*	611 ± 500	7.670	6.276	0.257	a,d
3-C1	3		4.4	AF126	4	±45		2.000	0.038	0.0760	-65	490 ± 400	6.205	5.066	0.083	a,d at t.a.
(2)	5		4.4	AF126	4	±45		2.000	0.038	0.0760	-65	490 ± 400	6.205	5.066	0.732	a,d at t.a.
	7	BP907(2Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	-65	427 ± 350	5.407	4.432	0.155	a,d at t.a.
	9	+	4.4	AF126	4	±45		2.000	0.038	0.0760	75	270 ± 221	3.426	2.810	R.O.	g
		XP251S	4.4	AF126	4	±45		2.000	0.038	0.0760		330 ± 270	4.177	3.417	8.576	a,d at t.a.
	11	(2 Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	75	390 ± 319	4.939	4.040	R.O.	g
	12		4.4	AF126	4	±45		2.010	0.038	0.0764	75	390 ± 319	4.919	4.024	R.O.	g
3-C2	2	BP907(2Ply)	4.4	AF126	4	±45		2.001	0.038	0.0760	75**	428 ± 350	5.454	4.460	0.313	c at t.a.
(3)	4	+	4.4	AF126	4	±45		2.005	0.038	0.0760	75**	367 ± 300	4.668	3.815	3.148	a,d at t.a.
	6	XP251S	4.4	AF126	4	±45		2.025	0.038	0.0769	75**	397 ± 325	4.999	4.093	1.443	c,d at t.a.
		(2 Ply)														
4-A1	1		4.4	AF126	4	±45	A	2.020	0.038	0.0768	-65	490 ± 400	6.364	5.195	0.046	a,d
	2		4.4	AF126	4	±45	A	2.000	0.038	0.0760	-65	427 ± 350	5.618	4.605	0.353	a,d at t.a.
	3	BP907(2Ply)	4.4	AF126	4	±45	A	1.985	0.038	0.0754	75	390 ± 319	5.181	4.237	6.646	a
	5	+	4.4	AF126	4	±45	A	1.995	0.038	0.0758	75	410 ± 336	5.430	4.450	2.414	a
	7	XP251S	4.4	AF126	4	±45	A	2.000	0.038	0.0760	75**	Gage failed no data obtained.				
	9	(2 Ply)	4.4	AF126	4	±45	A	1.992	0.038	0.0757	75**	390 ± 319	5.174	4.232	0.015	a
4-A2	5	BP907(2Ply)	4.4	AF126	4	±45	A	1.990	0.038	0.0756	-65	390 ± 319	5.215	4.265	3.613	a
	7	+	4.4	AF126	4	±45	A	2.000	0.038	0.0760	75	410 ± 336	5.455	4.470	0.004	a
	9	XP251S	4.4	AF126	4	±45	A	2.000	0.038	0.0760	75**	390 ± 319	5.189	4.244	0.012	a
		(2 Ply)														

TABLE XII. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft^3)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.^{2})	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Flexure Strength: Cycles to Failure (x 10^6)	Type of Failure
4-B1	1		4.4	AF126	4	±45		2.028	0.038	0.0770	-65	490 ± 400	6.149	5.020	0.712	a,d at t.a.
(2)	3		4.4	AF126	4	±45		2.024	0.038	0.0769	-65	427 ± 350	5.369	4.401	8.875	c,d at t.a.
	5	BP907(2Ply)	4.4	AF126	4	±45		2.005	0.038	0.0761	-65	551 ± 450	6.994	5.712	0.445	a,d at t.a.
	7	+	4.4	AF126	4	±45		2.014	0.038	0.0765	75	410 ± 336	5.191	4.254	2.706	d at t.a.
	9	XP251S	4.4	AF126	4	±45		2.026	0.038	0.0769	75	410 ± 336	5.150	4.221	2.244	d at t.a.
	11	(2 Ply)	4.4	AF126	4	±45		2.025	0.038	0.0769	75	410 ± 336	5.158	4.227	3.308	d at t.a.
4-B2	8	BP907(2Ply)	4.4	AF126	4	±45		2.012	0.038	0.0764	75**	428 ± 350	5.404	4.419	0.131	a at t.a.
(2)	10	+	4.4	AF126	4	±45		2.023	0.038	0.0768	75**	367 ± 300	4.622	3.778	0.597	a at t.a.
	12	XP251S	4.4	AF125	4	±45		2.020	0.038	0.0767	75**	306 ± 250	3.869	3.161	1.414	a at t.a.
		(2 Ply)														
4-B3	1	BP907(2Ply)	4.4	AF126	4	±45		1.981	0.038	0.0752	-65*	551 ± 450	6.997	5.699	2.370	d at t.a.
(2)	4	+	4.4	AF126	4	±45		1.973	0.038	0.0749	75***	480 ± 391	6.115	4.982	4.411	a
	7	XP251S	4.4	AF126	4	±45		1.977	0.038	0.0751	-65*	480 ± 391	6.125	4.990	R.O.	g
	8	(2 Ply)	4.4	AF126	4	±45		1.950	0.038	0.0741	-65*	612 ± 500	7.903	6.457	0.623	c at t.a.
4-B4	1		4.4	AF126	4	±45		2.000	0.038	0.0760	75*	410 ± 336	5.170	4.235	3.758	a,d at t.a.
(3)	3	BP907(2Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	75***	410 ± 336	5.162	4.231	0.251	
	5	+	4.4	AF126	4	±45		2.000	0.038	0.0760	75*	427 ± 350	5.375	4.400	5.497	a,d at t.a.
	7	XP251S	4.4	AF126	4	±45		2.000	0.038	0.0760	75***	410 ± 336	5.162	4.231	10.076	g
	9	(2 Ply)	4.4	AF126	4	±45		2.000	0.038	0.0760	75*	551 ± 450	6.940	5.665	0.030	a at t.a.
4-C1	4		4.4	AF126	4	±45		1.960	0.038	0.0745	-65	490 ± 400	6.363	5.194	0.700	c at t.a.
(2)	5		4.4	AF126	4	±45		1.950	0.038	0.0741	-65	427 ± 350	5.568	4.564	0.310	a at t.a.
	6	BP907(2Ply)	4.4	AF126	4	±45		1.957	0.038	0.0743	-65	390 ± 319	5.077	4.153	1.042	a at t.a.
	8	+	4.4	AF126	4	±45		1.950	0.038	0.0741	75	410 ± 336	5.356	4.390	2.430	d at t.a.
	9	XP251S	4.4	AF126	4	±45		1.944	0.038	0.0738	75	410 ± 336	5.378	4.407	3.415	d at t.a.
	10	(2 Ply)	4.4	AF126	4	±45		1.951	0.038	0.0741	75	410 ± 336	5.359	4.392	1.838	d at t.a.
4-C2	1	BP907(2Ply)	4.4	AF126	4	±45		2.006	0.038	0.0763	75**	306 ± 250	3.894	3.181	1.355	a at t.a.
(3)	3	+	4.4	AF126	4	±45		2.004	0.038	0.0762	75**	367 ± 300	4.665	3.814	2.635	a,d at t.a.
	5	XP251S	4.4	AF126	4	±45		2.008	0.038	0.0764	75**	427 ± 350	5.417	4.440	0.039	a at t.a.
		(2 Ply)														
5-A1	3	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	-65	1170 ± 957	6.894	5.713	0.079	a
(4)	5	+	4.4	None	8	±45		2.010	0.080	0.1608	-65	979 ± 800	5.808	4.752	3.640	a,d
	7	1002S(4Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75	390 ± 319	2.326	1.902	R.O.	g
	9	+	4.4	None	8	±45		2.000	0.080	0.1600	75	390 ± 319	2.328	1.904	R.O.	g
	10	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75**	970 ± 800	5.790	4.776	0.013	a
	11		4.4	None	8	±45		2.000	0.080	0.1600	75**	970 ± 800	5.790	4.776	0.012	a

TABLE XII. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft³)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.²)	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Flexure Strength: Cycles to Failure (x 10⁶)	Type of Failure
5-A2	3	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	-65	1170 ± 957	6.991	5.718	5.503	c
(4)	5	+	4.4	None	8	±45		2.020	0.080	0.1616	75	1170 ± 957	6.928	5.667	0.022	d at t.a.
	11	1002S(4Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75**	918 ± 750	5.501	4.494	0.009	a
		+														
		BP907(2Ply)														
5-B1	2	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	-65	1170 ± 957	6.840	5.595	2.848	c at t.a.
(5)	4	+	4.4	None	8	±45		2.000	0.080	0.1600	-65	1410 ± 1155	8.270	6.770	0.070	a at t.a.
	6	1002S(4Ply)	4.4	None	8	±45		2.000	0.080	0.1600	-65	1282 ± 1050	7.500	6.140	0.209	a at t.a.
	8	+	4.4	None	8	±45		2.000	0.080	0.1600	75	915 ± 750	5.360	4.393	4.396	d at t.a.
	10	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75	1170 ± 957	6.847	5.600	0.003	d at t.a.
	12		4.4	None	8	±45		2.000	0.080	0.1600	75	1010 ± 825	5.916	4.832	1.455	d at t.a.
5-B2	3	BP907(2Ply)	4.4	None	8	±45		2.013	0.080	0.1610	75**	915 ± 750	5.305	4.349	0.051	a
(5)	5	+	4.4	None	8	±45		2.012	0.080	0.1610	75**	915 ± 750	5.298	4.343	0.203	a
	7	1002S(4Ply)	4.4	None	8	±45		2.016	0.080	0.1613	75**	1010 ± 825	5.847	4.776	0.015	a
		+														
		BP907(2Ply)														
5-B3	6	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75***	915 ± 750	5.330	4.368	0.025	a
(5)	8	+	4.4	None	8	±45		2.000	0.080	0.1600	-65*	1410 ± 1090	8.236	6.746	0.044	a at t.a.
	10	1002S(4Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75***	855 ± 700	4.989	4.085	0.041	a
	12	+	4.4	None	8	±45		2.000	0.080	0.1600	-65*	1410 ± 1155	8.246	6.754	0.149	a,d at t.a.
		BP907(2Ply)														
5-B4	1	BP907(2Ply)	4.4	None	8	±45		2.010	0.080	0.1608	-65*	1170 ± 957	6.826	5.583	R.O.	a,d at t.a.
(5)	4	+	4.4	None	8	±45		2.000	0.080	0.1600	75***	1010 ± 825	5.916	4.832	0.019	a
	7	1002S(4Ply)	4.4	None	8	±45		2.020	0.080	0.1616	75*	1010 ± 825	5.860	4.790	4.584	a at t.a.
	10	+	4.4	None	8	±45		2.000	0.080	0.1600	75*	1170 ± 957	6.873	5.622	0.021	a at t.a.
	12	BP907(2Ply)	4.4	None	8	±45		2.000	0.080	0.1600	75*	1010 ± 825	5.933	4.846	0.776	a at t.a.
5-C2	1		4.4	None	8	±45		1.980	0.080	0.1584	-65	1170 ± 957	6.860	5.610	1.466	a,d at t.a.
(6)	3		4.4	None	8	±45		1.980	0.080	0.1584	-65	1410 ± 1155	8.240	6.750	0.072	a,d at t.a.
	8	BP907(2Ply)	4.4	None	8	±45		1.985	0.080	0.1588	-65	1282 ± 1050	7.480	6.125	0.358	a at t.a.
	5	+	4.4	None	8	±45		1.980	0.080	0.1584	75	1080 ± 825	5.900	4.810	0.911	a at t.a.
	7	1002S(4Ply)	4.4	None	8	±45		1.982	0.080	0.1586	75	1170 ± 957	6.820	5.570	0.023	a at t.a.
	9	+	4.4	None	8	±45		1.985	0.080	0.1588	75	915 ± 750	5.270	4.320	R.O.	g
	2	BP907(2Ply)	4.4	None	8	±45		1.988	0.080	0.1590	75**	915 ± 750	5.322	4.362	0.259	a,d at ta
	4		4.4	None	8	±45		1.981	0.080	0.1585	75**	978 ± 800	5.709	4.670	0.029	a,d at t.a.
	6		4.4	None	8	±45		1.985	0.080	0.1588	75**	1010 ± 825	5.873	4.797	0.015	a,d at t.a.
733	1	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	122 ± 100	2.575	2.111	R.O.	g
(10)	3	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	183 ± 150	3.862	3.166	R.O.	g
	5	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	220 ± 180	4.643	3.799	0.008	a
	7	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	208 ± 170	4.390	3.588	R.O.	g
	8	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	211 ± 173	4.453	3.651	6.445	a at t.a.
	9	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	214 ± 175	4.516	3.693	0.921	a at t.a.
	10	BP907/143	4.4	None	2	±45		2.000	0.023	0.0460	75	215 ± 176	4.538	3.715	0.089	a at t.a.
	11	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	214 ± 174	4.527	3.672	0.038	a at t.a.
	12	BP907 /143	4.4	None	2	±45		2.000	0.023	0.0460	75	217 ± 177	4.580	3.742	0.039	a at t.a.

TABLE XII. CONTINUED

Panel Number	Specimen Number	Material: Face Material	Material: Sandwich Core Density (lb/ft³)	Material: Adhesive	(3) Number of Plies	(4) Ply Orientation (Degrees)	Cure	Dimensions: Width (In.)	Dimensions: Thick (In.)	Dimensions: Area (In.²)	Test Temp (°F)	Flexure Strength: Applied Moment (In.-Lb)	Flexure Strength: Stress (ksi) Mean	Flexure Strength: Stress (ksi) Alt	Cycles to Failure (x 10⁶)	Type of Failure
3-B1 (2)	6	BP907(2Ply) +	4.4	AF126	4	±45		2.025	0.0375	0.07594	75*	427 ± 350	5.421	4.443	3.400×10^6	g
	12	XP251S(2Ply)	4.4	AF126	4	±45		2.025	0.0415	0.08404	75*	390 ± 319	4.491	3.673	0.18×10^6	d
4-B1 (2)	2	BP907(2Ply) +	4.4	AF126	4	±45		2.048	0.038	0.07782	75*	397 ± 325	4.896	4.008	7.534×10^6	g
	4	XP251S(2Ply)	4.4	AF126	4	±45		2.044	0.045	0.09198	75*	397 ± 325	4.130	3.382	(Δ)	g
	6		4.4	AF126	4	±45		2.050	0.030	0.06150	75*	460 ± 365	7.158	5.836	0.509×10^6	d
5-B1 (5)	3	BP907(2Ply) +	4.4	None	8	±45		2.025	0.075	0.15187	75*	1100 ± 900	6.737	5.513	R.O.	g
	5	1002S(4Ply) +	4.4	None	8	±45		2.025	0.075	0.15187	75*	1344 ± 1100	8.232	6.737	0.065×10^6	d
	11	BP907(2Ply)	4.4	None	8	±45		2.025	0.075	0.15187	75*	1222 ± 1000	7.485	6.125	0.025×10^6	a

(Δ) Stopped at 0.460×10^6 and reloaded at 489 ± 400 and failed (amplitude) after 0.350×10^6 cycles.

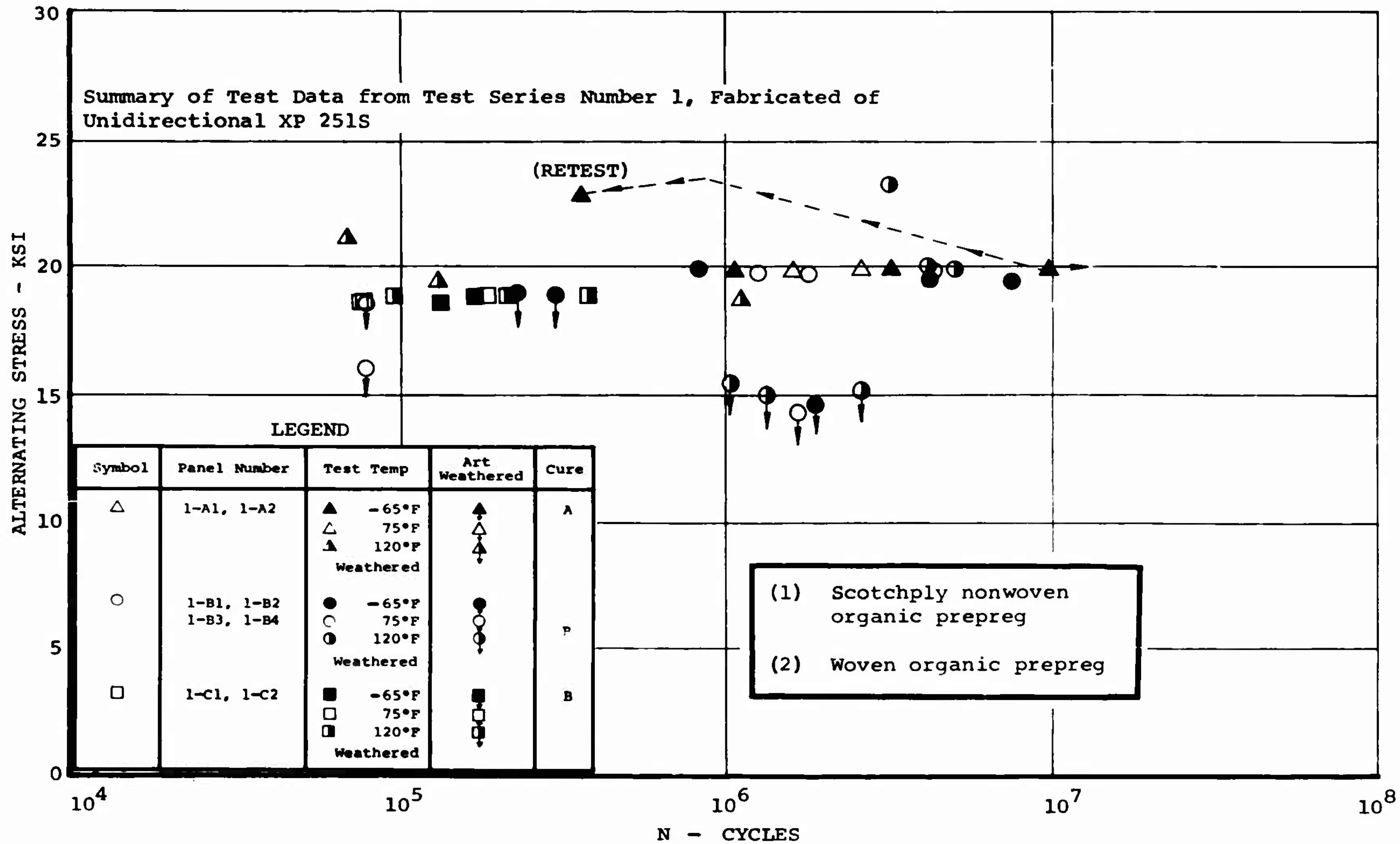


Figure 71. S-N Curve for Sandwich Beams Constructed of Aluminum Core and Laminated Epoxy Resin Faces Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F and 75°F. Stress Ratio (R) = 0.10.

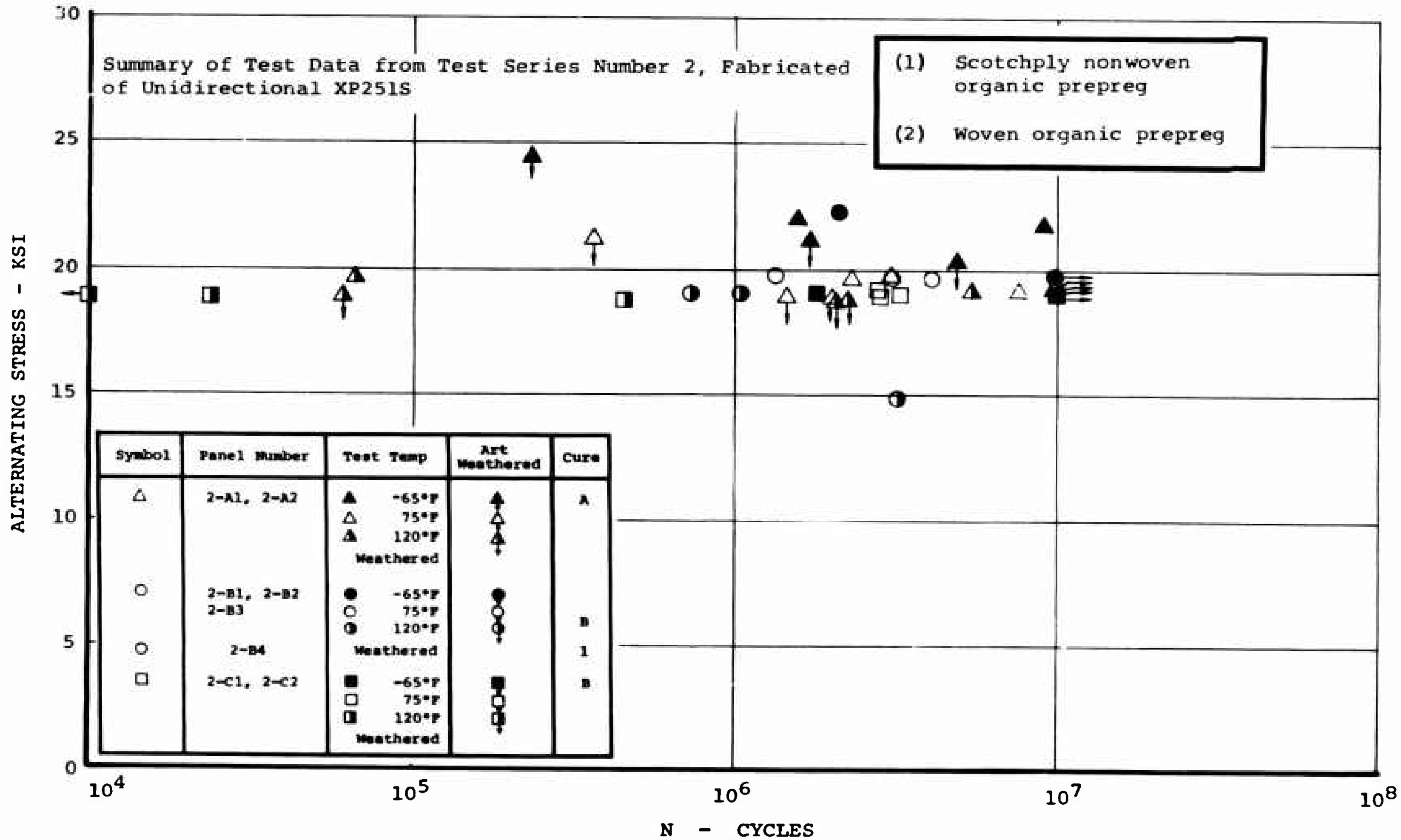


Figure 72. S-N Curve for Sandwich Beams Constructed of Aluminum Core and Laminated Epoxy Resin Faces Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F and 75°F. Stress Ratio (R) = 0.10 .

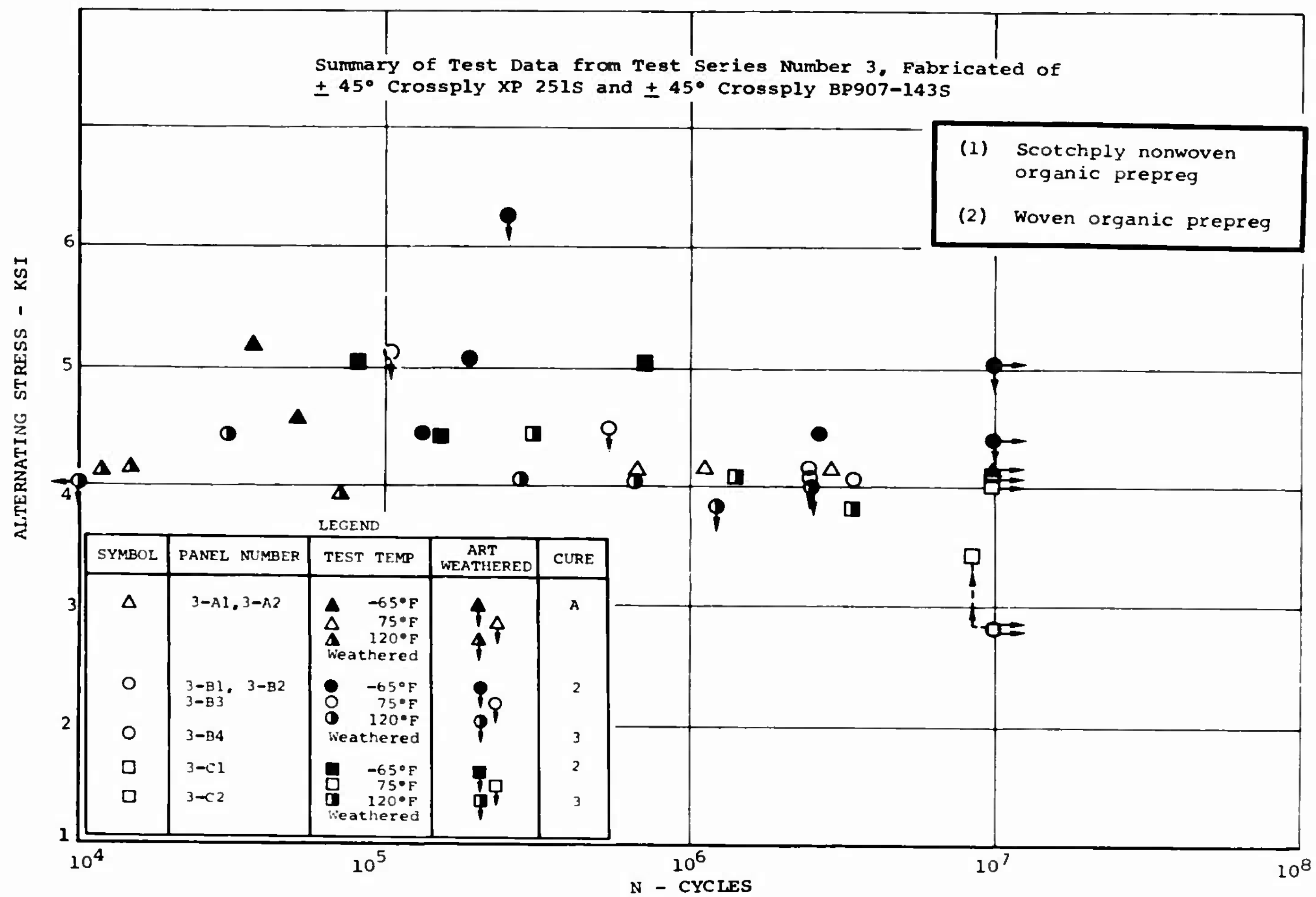


Figure 73. S-N Curve for Sandwich Beams Constructed of Aluminum Core and Laminated Epoxy Resin Faces Reinforced with S-Glass Fibers and 143S-Style Fabric and Tested at -65°F and 75°F. Stress Ratio (R) = 0.10.

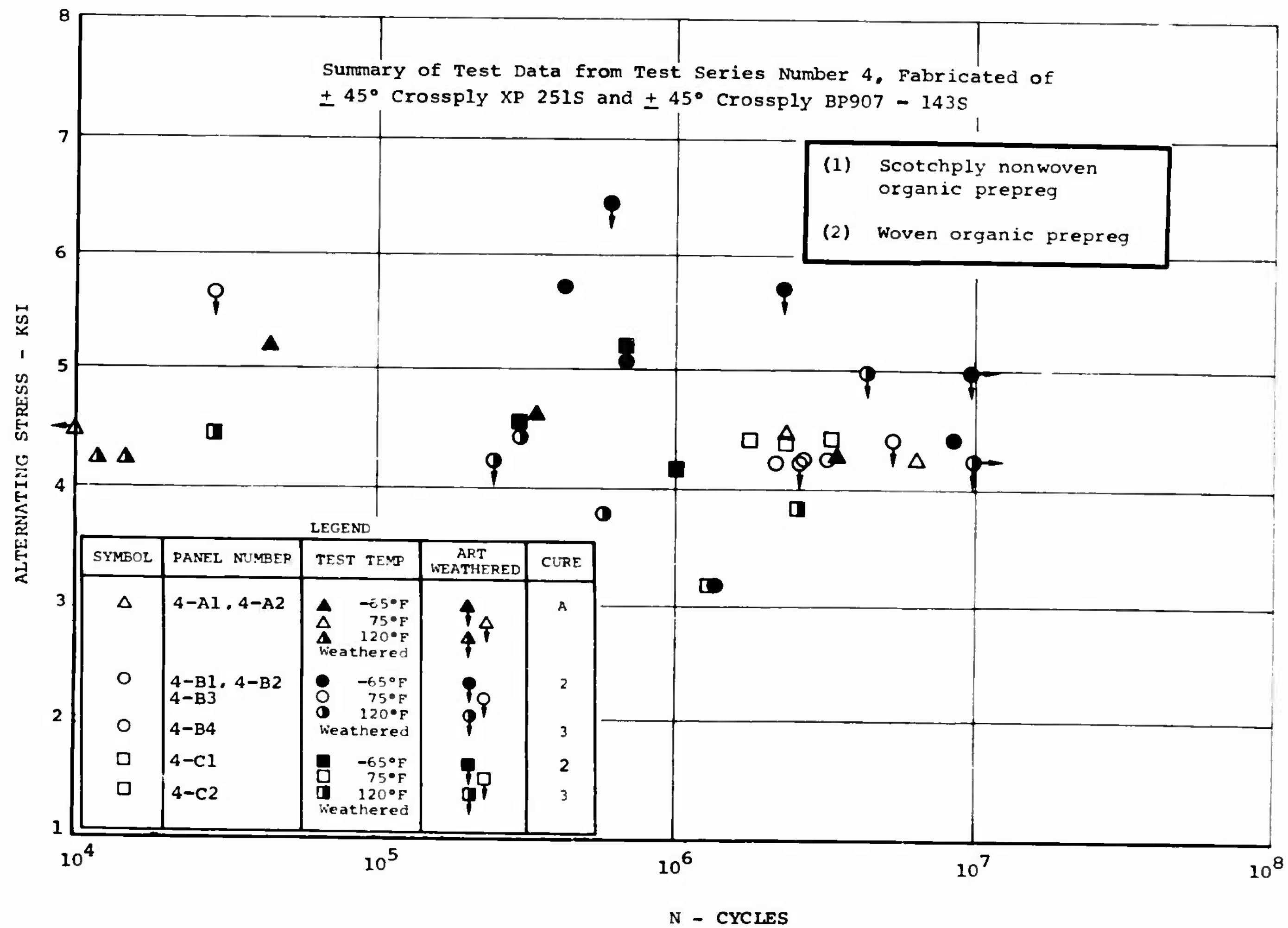


Figure 74. S-N Curve for Sandwich Beams Constructed of Aluminum Core and Laminated Epoxy Resin Faces Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F and 75°F. Stress Ratio (R) = 0.10.

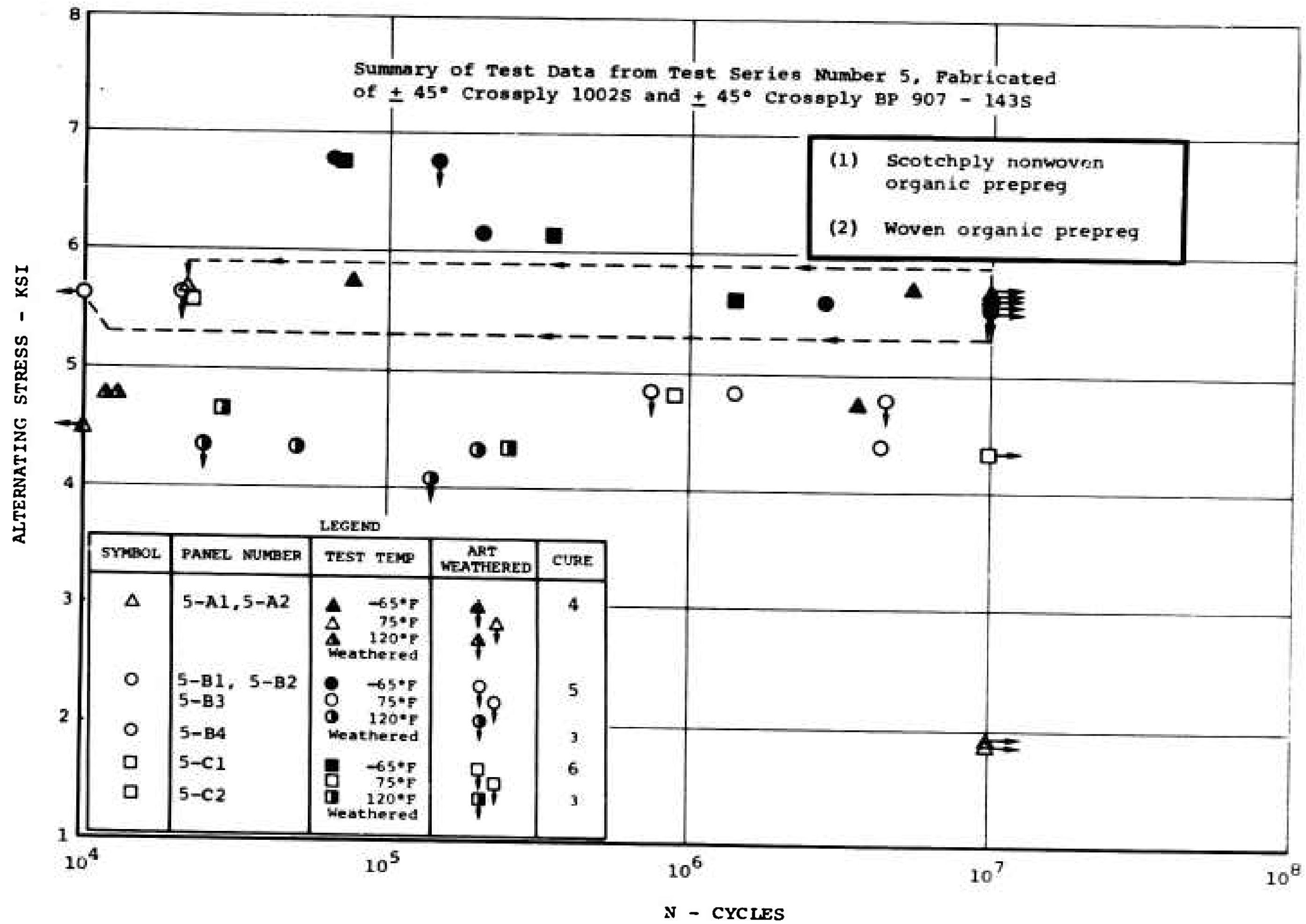


Figure 75. S-N Curve for Sandwich Beams Constructed of Aluminum Core and Laminated Epoxy Resin Faces Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F and 75°F. Stress Ratio (R) = 0.10.

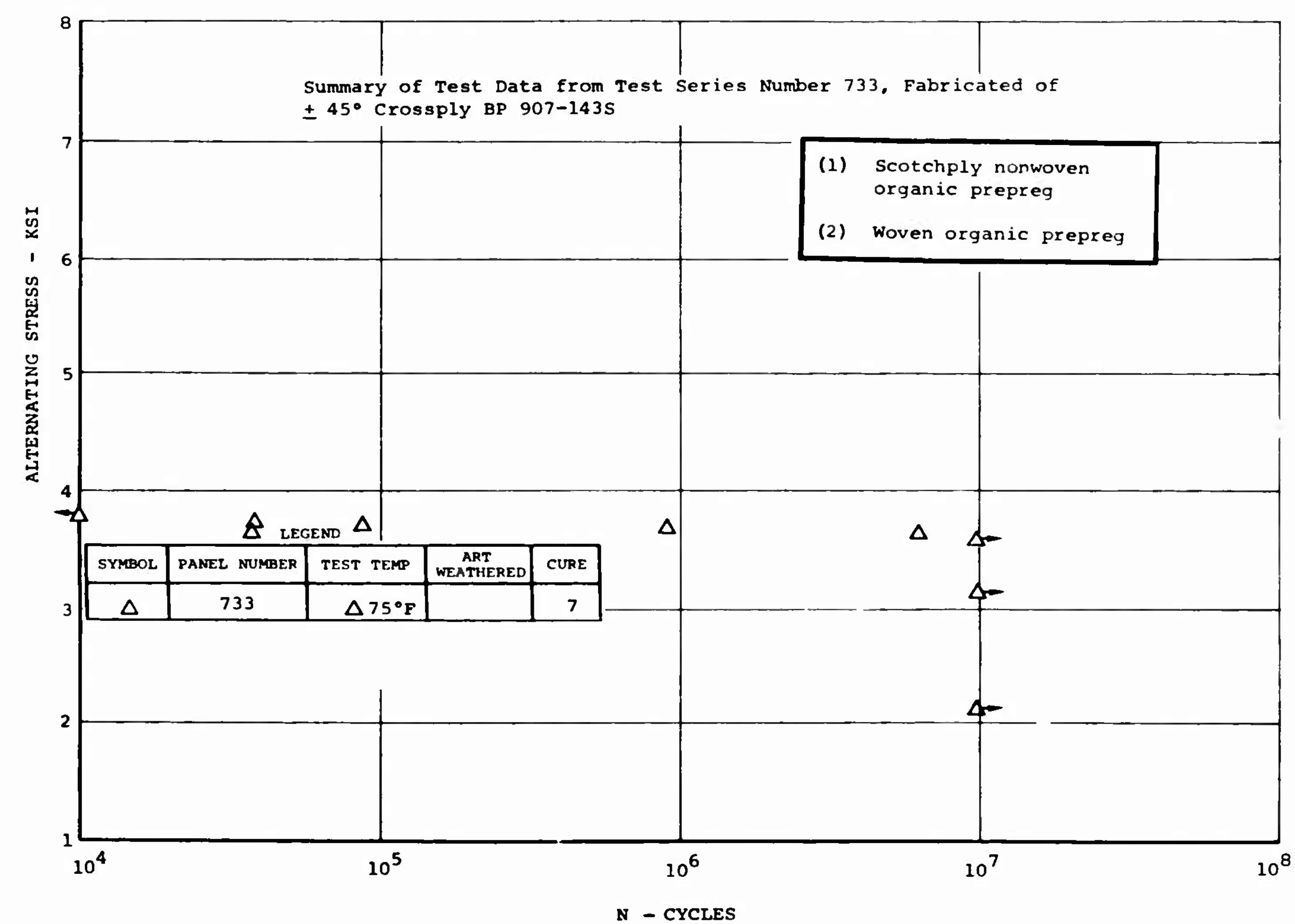


Figure 76. S-N Curve for Sandwich Beams Constructed of Aluminum Core and Laminated Epoxy Resin Faces Reinforced with (1) S-Glass Fibers and (2) 143S-Style Fabric and Tested at -65°F and 75°F. Stress Ratio (R) = 0.10.

TABLE XIII. TORSIONAL PROPERTIES OF FATIGUE AND STATICALLY TESTED TORSION TUBES FABRICATED FROM (1) SCOTCHPLY EPOXY RESIN XP251S, 1002S, AND (2) BP907-143S AND TESTED AT -65°F, 75°F, AND 160°F.

Tube Number	Specimen Number	Type of Test	Material	Number of Plies	(3) Wrap Angle (Degrees)	Cure	Wall Thickness (In.)	Test Temp (°F)	Torsional Strength: Applied Torque (In.-Lb)	Torsional Strength: Shear Stress (psi)	Torsional Strength: Cycles to Failure (x 10^6)	Torsional Strength: Shear Modulus (10^6)	Stress Ratio (R)	Test Result
	1	Static	1002S	7	0	E	0.060	-65	1325	7049	-	0.699	-	Specimen Failure
TU-3	2	Static	1002S	7	0	E	0.060	160	1277	6750	-	0.317	-	Specimen Failure
	3	Static	1002S	7	0	E	0.060	75	1519	8030	-	0.508	-	Specimen Failure
	1	Static	1002S	7	0	E	0.067	-65	2150	10275	-	0.574	-	Specimen Failure
TU-18	2	Static	1002S	7	0	E	0.067	75	1900	9092	-	0.501	-	Specimen Failure
	3	Static	1002S	7	0	E	0.070	160	1533	7034	-	0.389	-	Specimen Failure
	1	Static	1002S	7	0	E	0.066	-65	2588	12546	-	0.709	-	Specimen Failure
TU-21	2	Static	1002S	7	0	E	0.065	160	1183	5787	-	0.569	-	Specimen Failure
	3	Static	1002S	7	0	E	0.066	75	1200	5851	-	0.610	-	Specimen Failure
	1	Fatigue	1002S	7	0	E	0.066	75	0±1000	4828	0.018	0.740	-1	Amplitude
TU-22	2	Fatigue	1002S	7	0	E	0.069	-65	0± 680	3203	0.007	1.367	-1	Amplitude
	3	Fatigue	1002S	7	0	E	0.067	-65	0± 680	3240	0.007	0.808	-1	Amplitude
	1	Fatigue	1002S	7	0	E	0.069	-65	0± 550	2563	0.014	0.846	-1	Failure
TU-24	2	Fatigue	1002S	7	0	E	0.069	75	0±800	3722	10.028	0.375	-1	R.O. - Ultimate
	3	Fatigue	1002S	7	0	E	0.071	75	0±900	4086	10.037	0.672	-1	R.O. - Amplitude
	1	Static	XP251S	8	+45	E	0.060	75	11450	61041	-	1.925	-	Specimen Failure
TX-7	2	Static	XP251S	8	±45	E	0.060	-65	9163	48918	-	3.949	-	Specimen Failure
	3	Static	XP251S	8	±45	E	0.070	160	5688	26485	-	2.476	-	Specimen Failure
	1	Static	XP251S	8	±45	E	-	-	-	-	-	-	-	Damaged Tube
TX-9	2	Static	XP251S	8	±45	E	-	-	-	-	-	-	-	Damaged Tube
	3	Static	XP251S	8	±45	E	-	-	-	-	-	-	-	Damaged Tube
	1	Static	XP251S	8	±45	E	0.061	-65	11500	60328	-	4.650	-	Specimen Failure
TX-11	2	Fatigue	XP251S	8	±45	E	0.060	75	3508±3508	18943	0.550	2.363	0	Failure
	3	Fatigue	XP251S	8	±45	E	0.063	75	3600±3600	18347	0.001	-	0	Failed on Start

(1) - Nonwoven organic prepreg
(2) - Woven organic prepreg
(3) - Orientation of fibers relative to tube longitudinal axis (BP 907-143S wrapped ±45° to warp)

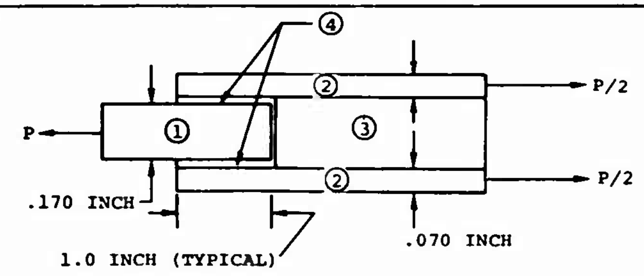
R.O. - Runout

Cure
E - 1 Hr at 280-290°F + 1 Hr at 330-340°F at 85 psig, vented
F - 1/2 Hr at 175-185°F + 1/2 Hr at 280-290°F, 1 Hr at 330-340°F at 85 psig, vented

TABLE XIII. CONTINUED

Tube Number	Specimen Number	Type of Test	Material	Number of Plies	(3) Wrap Angle (Degrees)	Cure	Wall Thickness (In.)	Test Temp. (°F)	Torsional Strength: Applied Torque (In-Lb)	Torsional Strength: Shear Stress (psi)	Torsional Strength: Cycles to Failure ($\times 10^6$)	Torsional Strength: Shear Modulus (10^6)	Stress Ratio (R)	Test Result
	1	Fatigue	XP251S	8	±45	E	0.060	75	3571±3571	18998	3.245	2.347	0	Failure
TX-12	2	Fatigue	XP251S	8	±45	E	0.060	75	3550±3550	18994	1.006	2.484	0	Failure
	3	Fatigue	XP251S	8	±45	E	0.060	75	3550±3550	18967	0.898	2.310	0	Failure
	1	Static	XP251S	8	±45	E	0.058	-65	10475	57768	-	2.693	-	Specimen Failure
TX-13	2	Static	XP251S	8	±45	E	0.056	160	7125	40311	-	2.107	-	Specimen Failure
	3	Static	XP251S	8	±45	E	0.065	160	5672	28317	-	1.954	-	Specimen Failure
	1	Static	BP907-143S	6	±45	F	0.082	-65	9750	39416	-	2.636	-	Specimen Failure
TX-25	2	Static	BP907-143S	6	±45	F	0.081	75	7725	31500	-	1.410	-	Specimen Failure
	3	Static	BP907-143S	6	±45	F	0.077	160	625	2663	-	0.934	-	Specimen Failure
	1	Static	BP907-143S	6	±45	F	0.081	-65	7734	31354	-	1.471	-	Specimen Failure
TX-27	2	Static	BP907-143S	6	±45	F	0.082	75	7975	32101	-	1.210	-	Specimen Failure
	3	Static	BP907-143S	6	±45	F	0.081	160	2344	9544	-	-	-	Tube Buckled
	1	Static	BP907-143S	6	±45	F	0.081	75	7823	31714	-	1.320	-	Specimen Failure
TX-28	2	Static	BP907-143S	6	±45	F	0.082	-65	8809	35339	-	1.560	-	Specimen Failure
	3	Static	BP907-143S	6	±45	F	0.080	160	1563	6400	-	-	-	Tube Buckled
	1	Fatigue	BP907-143S	6	±45	F	0.082	75	0±1900	7605	6.872	1.745	-1	Failure
TX-29	2	Fatigue	BP907-143S	6	±45	F	0.081	75	0±2000	8120	2.211	1.264	-1	Failure
	3	Fatigue	BP907-143S	6	±45	F	0.082	75	0±2100	8473	2.117	1.280	-1	Failure
	1	Fatigue	BP907-143S	6	±45	F	0.087	75	0±2000	7563	2.279	0.995	-1	Failure
TX-30	2	Fatigue	BP907-143S	6	±45	F	0.087	75	0±2500	9564	0.007	1.150	-1	Failure
	3	Fatigue	BP907-143S	6	±45	F	0.088	75	0±2250	8515	0.018	1.048	-1	Failure

TABLE XIV . FATIGUE AND STATIC PROPERTIES OF ADHESIVE BONDED DOUBLE LAP SHEAR JOINTS TESTED AT ROOM TEMPERATURE.



CONFIGURATION 1

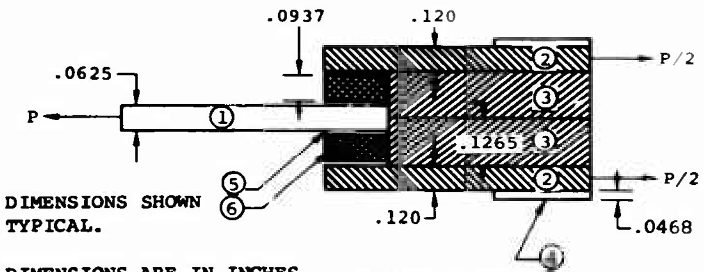
Specimen Number	Type of Test	Overlap Length (In.)	Bonded Area (In.^{2})	Test Temp (°F)	Static Strength: Load (Lb)	Static Strength: Bond Stress (ksi)	Fatigue Strength: * R	Fatigue Strength: Stress - ksi Mean	Fatigue Strength: Stress - ksi Alt	Fatigue Strength: Cycles to Failure (10^6)	Type of Failure
A-1	Fatigue	1.00	1.946	75			0.1	0.919	$\mp$0.750	0.198	Adherend
A-2	Fatigue	1.00	1.912	75			0.1	0.919	$\mp$0.750	0.242	Adherend
A-3	Fatigue	1.01	1.959	75			0.1	0.919	$\mp$0.750	0.335	Adherend
A-4	Fatigue	0.98	1.871	75			0.1	0.794	$\mp$0.650	1.365	Adherend
A-5	Fatigue	0.99	1.893	75			0.1	0.8555	$\mp$0.700	0.266	Adherend
A-6	Fatigue	0.95	1.854	75			0.1	0.733	$\mp$0.600	1.140	Adherend

* - Stress Ratio

1, 2, 3 - Alclad Aluminum (2024-T3)

4 - AF-126 Adhesive, Density 0.06 Lb/Ft^2

TABLE XIV. CONTINUED



NOTES: ALL DIMENSIONS SHOWN ARE TYPICAL.

ALL DIMENSIONS ARE IN INCHES.

CONFIGURATION 2

Specimen Number	Type of Test	Overlap Length (In.)	Bonded Area ($In.^2$)	Test Temp (°F)	Static Strength Load (Lb)	Static Strength Bond Stress (ksi)	Fatigue Strength * R	Fatigue Strength Stress - ksi Mean	Fatigue Strength Stress - ksi Alt	Fatigue Strength Cycles to Failure (10^6)	Type of Failure
B-2	Static	0.974	1.9421	75	6400	3.295					Adhesive
B-3	Static	0.958	1.9534	75	6600	3.379					Adhesive
B-5	Static	0.980	1.961	75	6340	3.233					Adhesive
B-8	Static	0.979	1.985	75	6340	3.194					Adhesive
B-9	Static	0.910	1.841	75	5700	3.096					Adhesive
			Average		6276	3.239					

1 Titanium (Ti - 6 Al - 4V)
2 XP251S - Unidirectional - (Precured)
3 XP251S - Unidirectional Filler - (Precured)
4 Alclad Aluminum (2024 - T3)
5 AF 126 Adhesive
6 XP251S - ±45° Crossply - (Precured)

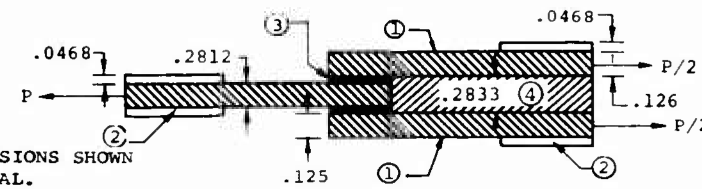
* - Stress Ratio

TABLE XIV. CONTINUED

(1) Specimen Number	Type of Test	Overlap Length (In.)	Bonded Area ($In.^2$)	Test Temp (°F)	Static Strength Load (Lb)	Static Strength Bond Stress (ksi)	Fatigue Strength * R	Fatigue Strength Stress - ksi Mean	Fatigue Strength Stress - ksi Alt	Fatigue Strength Cycles to Failure (10^6)	Type of Failure
D-1	Fatigue	0.93	1.832	75			0.1	1.10	∓0.900	0.004	Adhesive
D-4	Fatigue	0.94	1.852	75			0.1	1.028	∓0.842	0.010	Adhesive
D-5	Fatigue	0.95	1.872	75			0.1	0.919	∓0.750	0.010	Adhesive
D-8	Fatigue	0.95	1.875	75			0.1	0.868	∓0.710	0.034	Adhesive
D-10	Fatigue	0.945	1.880	75			0.1	0.610	∓0.500	0.140	Adhesive
D-11	Fatigue	0.945	1.862	75			0.1	0.550	∓0.450	0.055	Adhesive
D-2	Static	0.963	1.896	75	7160	3.776					Adhesive
D-3	Static	0.968	1.961	75	7500	3.824					Adhesive
D-6	Static	0.983	1.983	75	7260	3.661					Adhesive
D-7	Static	0.976	1.978	75	6210	3.139					Adhesive
D-9	Static	0.988	1.976	75	7290	3.689					Adhesive
			Average		7084	3.618					
B-1	Fatigue	0.96	1.891	75			0.1	0.611	∓0.50	0.121	Adhesive
B-4	Fatigue	0.955	1.857	75			0.1	0.550	∓0.45	0.146	Adhesive
B-6	Fatigue	0.96	1.873	75			0.1	0.4898	∓0.40	0.662	Adhesive
B-7	Fatigue	0.96	1.907	75			0.1	0.4277	∓0.35	3.192	Adhesive
B-10	Fatigue	0.97	1.862	75			0.1	0.5194	∓0.425	0.051	Adhesive
B-11	Fatigue	0.99	1.937	75			0.1	0.4583	∓0.375	0.525	Adhesive

(1) The cure for panel D was cycled three times as follows: Complete assembly for 1 hour at 330°-340°F at 50 psig (autoclave), heatup rate at 1.5°F/minute.

TABLE XIV. CONTINUED



NOTES: ALL DIMENSIONS SHOWN ARE TYPICAL.

ALL DIMENSIONS ARE IN INCHES.

Specimen Number	Type of Test	Overlap Length (In.)	Bonded Area (In.^{2})	Test Temp (°F)	Static Strength Load (Lb)	Static Strength Bond Stress (ksi)	Fatigue Strength R*	Fatigue Strength Stress - ksi Mean	Fatigue Strength Stress - ksi Alt	Fatigue Strength Cycles to Failure (10^6)	Type of Failure
C-2	Static	0.990	2.002	75	9460	4.725					Adhesive
C-4	Static	0.990	1.998	75	10,080	5.045					Adhesive
C-6	Static	0.995	1.998	75	10,440	5.225					Adhesive
C-8	Static	1.00	2.002	75	10,480	5.235					Adhesive
C-10	Static	1.00	2.008	75	10,500	5.229					Adhesive
			Average		10,192	5.092					

① BP907/143 S Glass Cloth Unidirectional (Precured)

② Alclad Aluminum (2024-T3) Doublers

③ AF 126 Adhesive

④ BP907/143 S Glass Cloth Unidirectional Filler - (Precured)

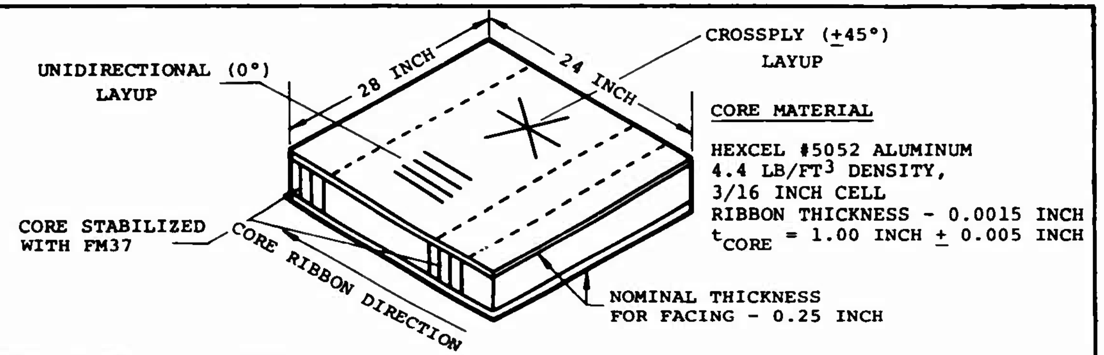
* - Stress Ratio

TABLE XIV. CONTINUED

Specimen Number	Type of Test	Overlap Length (In.)	Bonded Area ($In.^2$)	Test Temp (°F)	Static Strength: Load (Lb)	Static Strength: Bond Stress (ksi)	Fatigue Strength: * R	Fatigue Strength: Stress - ksi Mean	Fatigue Strength: Stress - ksi Alt	Fatigue Strength: Cycles to Failure (10^6)	Type of Failure
C1-1	Fatigue	0.98	1.979	75			0.1	1.10	$\mp$0.9	0.204	Adhesive
C1-3	Fatigue	1.00	2.016	75			0.1	1.10	$\mp$0.9	0.307	Adhesive
C1-5	Fatigue	1.00	2.014	75			0.1	0.978	$\mp$0.8	1.776	Adhesive
C1-7	Fatigue	1.00	2.002	75			0.1	1.10	$\mp$0.9	0.508	*Adhesive
C1-9	Fatigue	1.001	2.014	75			0.1	0.919	$\mp$0.75	3.694	Adhesive
C1-11	Fatigue	0.98	1.960	75			0.1	0.868	$\mp$0.71	6.586	Adhesive

* Previous runout at 610 ± 500 psi at 10.003 x 10^6 cycles

TABLE XV. FIBER GLASS SANDWICH TEST PANEL FABRICATION HISTORY



Series	Assembly	Step	Material Facing and Adhesive Layup on Core	Fiber Orientation	Assembly Cures and Sequence	Panel	Heatup Rate (°F/Min)	Remarks
1	A	1	4 Ply XP251S + AF126 (0.06 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	1 2	5.0 5.0	(A)
	B	1	4 Ply XP251S + AF126 (0.06 lb wt)	Parallel to Core Ribbon Direction	2 Hours at 330-340°F and 30 psig	1 2 3 4	5.8 5.0 4.0 4.0	(B)
	C	1	4 Ply XP251S + AF126 (0.06 lb wt)	Parallel to Core Ribbon Direction	2 Hours at 330-340°F and 30 psig	1 2	3.7 3.3	(B)
	C	2	Cured 1-C-Step 1 Panels	Parallel to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure	1 2		Oven Postcure
2	A	1	Uncured 4 Ply XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	1 2	5.4 6.5	(A)
	B	1	Uncured 4 Ply XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	2 Hours at 330-340°F and 30 psig Except Panel 2-B-4 at 330-340°F for 3.5 Hrs	1 2 3 4	 4.4 3.9	(B) (1)
	C	1	Uncured 4 Ply XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	2 Hours at 330-340°F and 30 psig	1 2	5.4 5.8	(B)
	C	2	Cured 2-C-Step 1 Panels	Parallel to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure	1 2		Oven Postcure

TABLE XV. CONTINUED

Series	Assembly	Step	Material Facing and Adhesive Layup on Core	Fiber Orientation	Assembly Cures and Sequence	Panel	Heatup Rate (°F/Min)	Remarks
3	A	1	BP907U + 2 Ply ±45° BP907/143S + AF126 (0.06 lb wt) + 2 Ply XP251S, Uncured	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	1 2	5.4 5.5	(A)
	B	1	BP907U + 2 Ply ±45° BP907/143S + 1 Ply 661 Nylon Peel Ply	±45° to Core Ribbon Direction	0.5 Hour at 180-190°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2 3 4	1.5 2.9 1.5 1.5	Heatup Rates are Average of 3 Cure Steps
	B	2	Cured 3-B-Step 1 Panels + AF126 (0.06 lb wt) + 2 Ply ±45° Precured XP251S	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 50 psig, Except Panel 3-B4 at 30 psig	1 2 3 4	1.3 1.3 1.3 1.2	(2) (3)
	C	1	BP907U + 2 Ply ±45° BP907/143S + 1 Ply 661 Nylon Peel Ply	±45° to Core Ribbon Direction	0.5 Hour at 180-190°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2	1.5 1.5	Heatup Rates are Average of 3 Cure Steps
	C	2	Cured 3-C-Step 1 Panels + AF126 (0.06 lb wt) + 2 Ply ±45° Precured XP251S	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 50 psig, Except Panel 3-C-2 at 30 psig	1 2	1.3 1.5	(2) (3)
	C	3	Cured 3-C-Step 2 Panels	±45° to Core Ribbon Direction	16 Hours postcure at 280°F and vacuum pressure	1 2		Oven Postcure

TABLE XV. CONTINUED

Series	Assembly	Step	Material Facing and Adhesive Layup on Core	Fiber Orientation	Assembly Cures and Sequence	Panel	Heatup Rate (°F/Min)	Remarks
	A	1	BP907U + 2 Ply ±45° BP907/143S + AF126 (0.03 lb wt) + 2 Ply XP251S, Uncured	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	1 2	1.5 1.5	(A)
	B	1	BP907U + 2 Ply ±45° BP907/143S + 1 Ply 661 Nylon Peel Ply	±45° to Core Ribbon Direction	0.5 Hour at 180-190°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2 3 4	1.5 1.5 1.5 1.5	Heatup Rates are Average of 3 Cure Steps
4	B	2	Cured 4-B-Step 1 Panels + AF126 (0.03 lb wt) + 2 Ply ±45° Precured XP251S	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 50 psig, Except Panel 4-B-4 at 30 psig	1 2 3 4	1.3 1.3 1.3 1.2	(2) (3)
	C		BP907U + 2 Ply ±45° BP907/143S + 1 Ply 661 Nylon Peel Ply	±45° to Core Ribbon Direction	0.5 Hour at 180-190°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2	1.5 1.5	Heatup Rates are Average of 3 Cure Steps
	C	2	Cured 4-C-Step 1 Panels + AF126 (0.03 lb wt) + 2 Ply ±45° Precured XP251S	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 50 psig, Except Panel 4-C-2 at 30 psig	1 2	1.3 1.5	(2) (3)

TABLE XV. CONTINUED

Series	Assembly	Step	Material Facing and Adhesive Layup on Core	Fiber Orientation	Assembly Cures and Sequence	Panel	Heatup Rate (°F/Min)	Remarks
4	C	3	Cured 4-C-Step 2 Panels	±45° to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure	1		Oven Postcure
5	A	1	BP907U + 2 Ply ±45° BP907/143S + 4 Ply ±45° 1002S + 2 Ply ±45° BP907/143S	±45° to Core Ribbon Direction	0.5 Hour at 175-185°F and 30 psig 0.5 Hour at 275-285°F and 30 psig 7 Hours at 330-340°F and 30 psig	1 2	1.5 1.5	Heatup Rates are Average of 3 Cure Steps (4)
	B	1	BP907U + 2 Ply ±45° BP907/143S + 4 Ply ±45° 1002S	±45° to Core Ribbon Direction	0.5 Hour at 175-185°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2 3 4	1.5 1.5 1.5 1.5	Heatup Rates are Average of 3 Cure Steps
	B	2	Cured 5-B-Step 1 Panels + 2 Ply ±45° BP907/143S	±45° to Core Ribbon Direction	0.5 Hour at 175-185°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2 3 4	1.5 1.5 1.5 1.5	Heatup Rates are Average of 3 Cure Steps (5)
	C	1	BP907U + 2 Ply ±45° BP907/143S	±45° to Core Ribbon Direction	0.5 Hour at 175-185°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2	1.5 1.5	Heatup Rates are Average of 3 Cure Steps
	C	2	Cured 5-C-Step 1 Panels + 4 Ply ±45° 1002S	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	1 2	1.5 1.5	(6)
	C	3	Cured 5-C-Step 2 Panels + 2 Ply ±45° BP907/143S	±45° to Core Ribbon Direction	0.5 Hour at 175-185°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	1 2	1.5 1.5	Heatup Rates are Average of 3 Cure Steps

TABLE XV. CONTINUED

Series	Assembly	Step	Material Facing and Adhesive Layup on Core	Fiber Orientation	Assembly Cures and Sequence	Panel	Heatup Rate (°F/Min)	Remarks
6-1	6-1	1	3 Ply 1002S + FM-1000 (0.5 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 50 psig, Vented	6-1	2.1	(7)
		2	Cured 6-1 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure			Oven Postcure
6-2	6-2	1	3 Ply 1002S + FM-1000 (0.5 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	6-2	4.1	(8)
		2	Cured 6-2 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure			Oven Postcure
7-1	7-1	1	4 Ply ±45° 1002S + FM-1000 (0.5 lb wt)	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	7-1	3.8	(8)
		2	Cured 7-1 Panel	±45° to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure			Oven Postcure
7-2	7-2	1	4 Ply ±45° 1002S + FM-1000 (0.5 lb wt)	±45° to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	7-2	4.3	(8)
		2	Cured 7-2 Panel	±45° to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure			Oven Postcure
8-1	8-1	1	4 Ply XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	8-1	4.9	(8)
		2	Cured 8-1 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280-290°F and Vacuum Pressure			Oven Postcure
8-2	8-2	1	4 Ply XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	8-2	5.0	(8)
		2	Cured 8-2 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure			Oven Postcure
9-1	9-1	1	4 Ply ±45° XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	9-1	5.0	(8)
		2	Cured 9-1 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280-290°F and Vacuum Pressure			Oven Postcure

TABLE XV. CONTINUED

Series	Assembly	Step	Material Facing and Adhesive Layup on Core	Fiber Orientation	Assembly Cures and Sequence	Panel	Heatup Rate (°F/Min)	Remarks
9-2	9-2	1	4 Ply ±45° XP251S + FM-1000 (0.05 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F and 30 psig	9-2	4.3	(8)
		2	Cured 9-2 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280-290°F and Vacuum Pressure			Oven Postcure
10-1	10-1	1	2 Ply BP907/143S + BP907U (0.0175 lb wt)	Parallel to Core Ribbon Direction	1 Hour at 330-340°F at 30 psig	10-1	4.8	(A)
10-2	10-2	1	2 Ply BP907/143S + BP907U (0.0175 lb wt)	Parallel to Core Ribbon Direction	0.5 Hour at 175-185°F and 30 psig 0.5 Hour at 280-290°F and 30 psig 1 Hour at 330-340°F and 30 psig	10-2	5.0	Heatup Rate is Average of 3 Cure Steps (9)
		2	Cured 10-2 Panel	Parallel to Core Ribbon Direction	16 Hours Postcure at 280°F and Vacuum Pressure			Oven Postcure

TABLE XVI. STRAIN GAGE CALIBRATIONS OF SANDWICH BEAM SPECIMENS MEASURED AT ROOM TEMPERATURE PRIOR TO FATIGUE TESTING.

NONWEATHERED

Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
1-A1-3	XP251S	0	4	8.42
1-A1-5	XP251S	0	4	8.20
1-A1-7	XP251S	0	4	8.19
1-A1-9	XP251S	0	4	7.76
1-A1-12	XP251S	0	4	7.87
1-B1-1	XP251S	0	4	8.02
1-B1-5	XP251S	0	4	7.56
1-B1-7	XP251S	0	4	8.05
1-B1-9	XP251S	0	4	7.98
1-B2-3	XP251S	0	4	7.75
1-B2-5	XP251S	0	4	7.70
1-C1-2	XP251S	0	4	7.39
1-C1-4	XP251S	0	4	7.45
1-C1-6	XP251S	0	4	7.00
1-C1-8	XP251S	0	4	6.74
1-C2-2	XP251S	0	4	7.68
1-C2-5	XP251S	0	4	7.54
2-A2-1	XP251S	0	4	7.84
2-A2-2	XP251S	0	4	7.69
2-A2-3	XP251S	0	4	7.78
2-A2-5	XP251S	0	4	8.07
2-A2-6	XP251S	0	4	7.66
2-A2-7	XP251S	0	4	7.59
2-B1-1	XP251S	0	4	8.03
2-B1-3	XP251S	0	4	7.99
2-B1-5	XP251S	0	4	8.19
2-B1-7	XP251S	0	4	8.06
2-B2-1	XP251S	0	4	8.05
2-B2-3	XP251S	0	4	8.00
2-C1-1	XP251S	0	4	7.53

*Beam flexural modulus based on average of 3 readings from load strain curve of 500$\mu\varepsilon$, 1000$\mu\varepsilon$, and 1500$\mu\varepsilon$. The modulus was obtained using the following expressions:

$$\sigma_f = \frac{3P}{2t(1+t)}$$

$$E_B = \frac{\sigma_f}{\mu\varepsilon}$$

E_B = Beam Flexural Modulus, psi
σ_f = Facing Stress, psi
P = Applied Load, lb
t = Facing Thickness, in.
$\mu\varepsilon$ = Micro-Strain, in./in.

TABLE XVI. CONTINUED

NONWEATHERED

Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
2-C1-3	XP251S	0	4	8.09
2-C1-5	XP251S	0	4	8.15
2-C1-7	XP251S	0	4	8.07
2-C1-9	XP251S	0	4	8.45
2-C1-12	XP251S	0	4	8.31
3-A1-3	BP907-143S XP251S	±45 ±45	2 2	2.58
3-A1-5	BP907-143S XP251S	±45 ±45	2 2	2.77
3-A1-7	BP907-143S XP251S	±45 ±45	2 2	2.53
3-A1-9	BP907-143S XP251S	±45 ±45	2 2	2.41
3-A2-3	BP907-143S XP251S	±45 ±45	2 2	2.55
3-A2-7	BP907-143S XP251S	±45 ±45	2 2	2.66
3-B1-3	BP907-143S XP251S	±45 ±45	2 2	2.65
3-B1-5	BP907-143S XP251S	±45 ±45	2 2	2.62
3-B1-7	BP907-143S XP251S	±45 ±45	2 2	2.68
3-B1-9	BP907-143S XP251S	±45 ±45	2 2	2.69
3-B2-5	BP907-143S XP251S	±45 ±45	2 2	2.43
3-B2-7	BP907-143S XP251S	±45 ±45	2 2	2.59
3-C1-3	BP907-143S XP251S	±45 ±45	2 2	2.66
3-C1-5	BP907-143S XP251S	±45 ±45	2 2	2.81
3-C1-7	BP907-143S XP251S	±45 ±45	2 2	2.82
3-C1-9	BP907-143S XP251S	±45 ±45	2 2	2.72
3-C1-11	BP907-143S XP251S	±45 ±45	2 2	2.78
3-C1-13	BP907-143S XP251S	±45 ±45	2 2	2.72
4-A1-1	BP907-143S XP251S	±45 ±45	2 2	2.53
4-A1-2	BP907-143S XP251S	±45 ±45	2 2	2.44

TABLE XVI. CONTINUED

NONWEATHERED

Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
4-A1-3	BP907-143S	±45	2	2.88
	XP251S	±45	2	
4-A1-5	BP907-143S	±45	2	2.99
	XP251S	±45	2	
4-A2-5	BP907-143S	±45	2	2.79
	XP251S	±45	2	
4-A2-7	BP907-143S	±45	2	2.34
	XP251S	±45	2	
4-B1-1	BP907-143S	±45	2	2.67
	XP251S	±45	2	
4-B1-3	BP907-143S	±45	2	2.72
	XP251S	±45	2	
4-B1-5	BP907-143S	±45	2	2.54
	XP251S	±45	2	
4-B1-7	BP907-143S	±45	2	2.70
	XP251S	±45	2	
4-B1-9	BP907-143S	±45	2	2.72
	XP251S	±45	2	
4-B1-11	BP907-143S	±45	2	2.77
	XP251S	±45	2	
4-C1-4	BP907-143S	±45	2	2.71
	XP251S	±45	2	
4-C1-5	BP907-143S	±45	2	2.56
	XP251S	±45	2	
4-C1-6	XP907-143S	±45	2	2.66
	XP251S	±45	2	
4-C1-8	BP907-143S	±45	2	2.43
	XP251S	±45	2	
4-C1-9	BP907-143S	±45	2	2.46
	XP251S	±45	2	
4-C1-10	BP907-143S	±45	2	2.55
	XP251S	±45	2	
5-A1-3	BP907-143S	±45	2	2.15
	1002S	±45	4	
	BP907-143S	±45	2	
5-A1-5	BP907-143S	±45	2	2.25
	1002S	±45	4	
	BP907-143S	±45	2	
5A1-7	BP907-143S	±45	2	2.22
	1002S	±45	4	
	BP907-143S	±45	2	
5-A1-9	BP907-143S	±45	2	2.17
	1002S	±45	4	
	BP907-143S	±45	2	

		TABLE XVI. CONTINUED		
		NONWEATHERED		
Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
	BP907-143S	±45	2	
5-A2-3	1002S	±45	4	2.18
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-A2-5	1002S	±45	4	2.25
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-B1-2	1002S	±45	4	2.06
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-B1-4	1002S	±45	4	2.05
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-B1-6	1002S	±45	4	2.13
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-B1-8	1002S	±45	4	2.08
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-B1-10	1002S	±45	4	2.09
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-B1-12	1002S	±45	4	2.08
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-C2-1	1002S	±45	4	2.18
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-C2-3	1002S	±45	4	2.20
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-C2-5	1002S	±45	4	2.09
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-C2-7	1002S	±45	4	2.22
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-C2-8	1002S	±45	4	2.19
	BP907-143S	±45	2	
	BP907-143S	±45	2	
5-C2-9	1002S	±45	4	2.17
	BP907-143S	±45	2	

TABLE XVI. CONTINUED				
NONWEATHERED				
Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
6-1	BP907-143S	±45	2	2.18
6-3	BP907-143S	±45	2	2.24
6-5	BP907-143S	±45	2	2.16
6-7	BP907-143S	±45	2	2.21
6-8	BP907-143S	±45	2	2.18
6-9	BP907-143S	±45	2	2.18
6-10	BP907-143S	±45	2	2.25
6-11	BP907-143S	±45	2	2.12
6-12	BP907-143S	±45	2	2.24

TABLE XVI. CONTINUED				
120° WEATHERED				
Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
1-A2-3	XP251S	0	4	7.77
1-A2-5	XP251S	0	4	7.74
1-A2-7	XP251S	0	4	7.45
1-B1-11	XP251S	0	4	7.97
1-B2-7	XP251S	0	4	8.15
1-B2-9	XP251S	0	4	7.74
1-C1-10	XP251S	0	4	7.33
1-C1-12	XP251S	0	4	7.78
1-C2-8	XP251S	0	4	7.18
2-A1-6	XP251S	0	4	7.33
2-A1-9	XP251S	0	4	7.94
2-A1-13	XP251S	0	4	8.30
2-B1-9	XP251S	0	4	7.71
2-B1-12	XP251S	0	4	8.20
2-B2-5	XP251S	0	4	7.99
2-C2-4	XP251S	0	4	7.76
2-C2-8	XP251S	0	4	6.96
2-C2-12	XP251S	0	4	7.72
3-A1-11	BP907-143S XP251S	±45 ±45	2 2	2.51
3-A1-13	BP907-143S XP251S	±45 ±45	2 2	2.44
3-A2-9	BP907-143S XP251S	±45 ±45	2 2	2.58
3-B1-11	BP907-143S XP251S	±45 ±45	2 2	2.48
3-B1-13	BP907-143S XP251S	±45 ±45	2 2	2.58
3-B2-9	BP907-143S XP251S	±45 ±45	2 2	2.56
3-C2-2	BP907-143S XP251S	±45 ±45	2 2	2.75
3-C2-4	BP907-143S XP251S	±45 ±45	2 2	2.84
3-C2-6	BP907-143S XP251S	±45 ±45	2 2	2.93
4-A1-7	BP907-143S XP251S	±45 ±45	2 2	2.65
4-A1-9	BP907-143S XP251S	±45 ±45	2 2	2.62
4-A2-9	BP907-143S XP251S	±45 ±45	2 2	2.35
4-B2-8	BP907-143S XP251S	±45 ±45	2 2	2.88

TABLE XVI. CONTINUED

120° WEATHERED

Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
4-B2-10	BP907-143S	±45	2	2.84
	XP251S	±45	2	
4-B2-12	BP907-143S	±45	2	2.76
	XP251S	±45	2	
4-C2-1	BP907-143S	±45	2	2.78
	XP251S	±45	2	
4-C2-3	BP907-143S	±45	2	2.76
	XP251S	±45	2	
4-C2-5	BP907-143S	±45	2	2.80
	XP251S	±45	2	
5-A1-10	BP907-143S	±45	2	2.17
	1002S	±45	4	
	BP907-143S	±45	2	
5-A1-11	BP907-143S	±45	2	2.17
	1002S	±45	4	
	BP907-143S	±45	2	
5-A2-11	BP907-143S	±45	2	2.18
	1002S	±45	4	
	BP907-143S	±45	2	
5-B2-3	BP907-143S	±45	2	2.09
	1002S	±45	4	
	BP907-143S	±45	2	
5-B2-5	BP907-143S	±45	2	2.09
	1002S	±45	4	
	BP907-143S	±45	2	
5-B2-7	BP907-143S	±45	2	2.20
	1002S	±45	4	
	BP907-143S	±45	2	
5-C2-2	BP907-143S	±45	2	2.24
	1002S	±45	4	
	BP907-143S	±45	2	
5-C2-4	BP907-143S	±45	2	2.22
	1002S	±45	4	
	BP907-143S	±45	2	
5-C2-6	BP907-143S	±45	2	2.24
	1002S	±45	4	
	BP907-143S	±45	2	

TABLE XVI. CONTINUED				
ARTIFICIALLY WEATHERED				
Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
1-B3-8	XP251S	0	4	8.02
1-B3-10	XP251S	0	4	7.70
1-B4-2	XP251S	0	4	7.83
1-B4-6	XP251S	0	4	8.01
1-B4-8	XP251S	0	4	7.86
1-B4-10	XP251S	0	4	8.70
2-B3-1	XP251S	0	4	8.60
2-B3-9	XP251S	0	4	7.48
2-B4-1	XP251S	0	4	8.49
2-B4-4	XP251S	0	4	8.48
2-B4-10	XP251S	0	4	8.11
2-B4-12	XP251S	0	4	8.10
3-B3-1	BP907 XP251S	±45 ±45	2 2	2.73
3-B3-5	BP907 XP251S	±45 ±45	2 2	2.89
3-B3-7	BP907 XP251S	±45 ±45	2 2	2.83
3-B4-4	BP907 XP251S	±45 ±45	2 2	2.79
3-B4-10	BP907 XP251S	±45 ±45	2 2	2.88
3-B4-12	BP907 XP251S	±45 ±45	2 2	3.00
4-B3-1	BP907 XP251S	±45 ±45	2 2	2.92
4-B3-7	BP907 XP251S	±45 ±45	2 2	2.85
4-B3-8	BP907 XP251S	±45 ±45	2 2	2.77
4-B4-1	BP907 XP251S	±45 ±45	2 2	2.94
4-B4-5	BP907 XP251S	±45 ±45	2 2	2.85
4-B4-9	BP907 XP251S	±45 ±45	2 2	2.88
5-B3-8	BP907 1002S BP907	±45 ±45 ±45	2 4 2	2.07

TABLE XVI. CONTINUED

ARTIFICIALLY WEATHERED

Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
5-B3-12	BP907	±45	2	2.22
	1002S	±45	4	
	BP907	±45	2	
5-B4-1	BP907	±45	2	2.41
	1002S	±45	4	
	BP907	±45	2	
5-B4-7	BP907	±45	2	2.24
	1002S	±45	4	
	BP907	±45	2	
5-B4-10	BP907	±45	2	2.21
	1002S	±45	4	
	BP907	±45	2	
5-B4-12	BP907	±45	2	2.28
	1002S	±45	4	
	BP907	±45	2	

TABLE XVI. CONTINUED

120°F WEATHERED AND ARTIFICIALLY WEATHERED

Specimen Number	Face Material	Fiber Orientation (Degrees)	Number of Plies	Average* Modulus (10^6 psi)
1-B3-6	XP251S	0	4	7.56
1-B3-12	XP251S	0	4	8.27
1-B4-4	XP251S	0	4	8.46
2-B3-3	XP251S	0	4	8.32
2-B3-6	XP251S	0	4	7.61
2-B4-7	XP251S	0	4	8.28
3-B3-3	BP907-143S	±45	2	2.92
	XP251S	±45	2	
3-B4-1	BP907-143S	±45	2	2.98
	XP251S	±45	2	
3-B4-7	BP907-143S	±45	2	2.95
	XP251S	±45	2	
4-B3-4	BP907-143S	±45	2	3.05
	XP251S	±45	2	
4-B4-3	BP907-143S	±45	2	2.90
	XP251S	±45	2	
4-B4-7	BP907-143S	±45	2	3.12
	XP251S	±45	2	
5-B3-6	BP907-143S	±45	2	2.23
	1002S	±45	4	
	BP907-143S	±45	2	
5-B3-10	BP907-143S	±45	2	2.08
	1002S	±45	4	
	BP907-143S	±45	2	
5-B4-4	BP907-143S	±45	2	2.22
	1002S	±45	4	
	BP907-143S	±45	2	

TABLE XVII. SPECIMEN CONDITIONING CATEGORY

Nonweathered	Tested at controlled temperatures of -65°F, 75°F, and 160°F
Weathered	Specimens conditioned in a condensing humidity chamber (100% humidity) at 120°F for 30 days and tested within 30 minutes at ambient temperatures.
Artificial Weathering	1) Specimens exposed to artificial sunshine (carbon elements) and rain in Atlas Weatherometer Chamber for 300 hours and tested within 30 days at ambient temperatures. 2) The amounts of exposure for a 300-hour run are as follows:
Natural Weathering	Specimens exposed to natural climatic conditions for periods from 6 months to 1 year and tested at ambient temperatures.

	Sun	Rain
Extreme	41%	78%
Low	26%	44%
Average	33.5%	61.0%

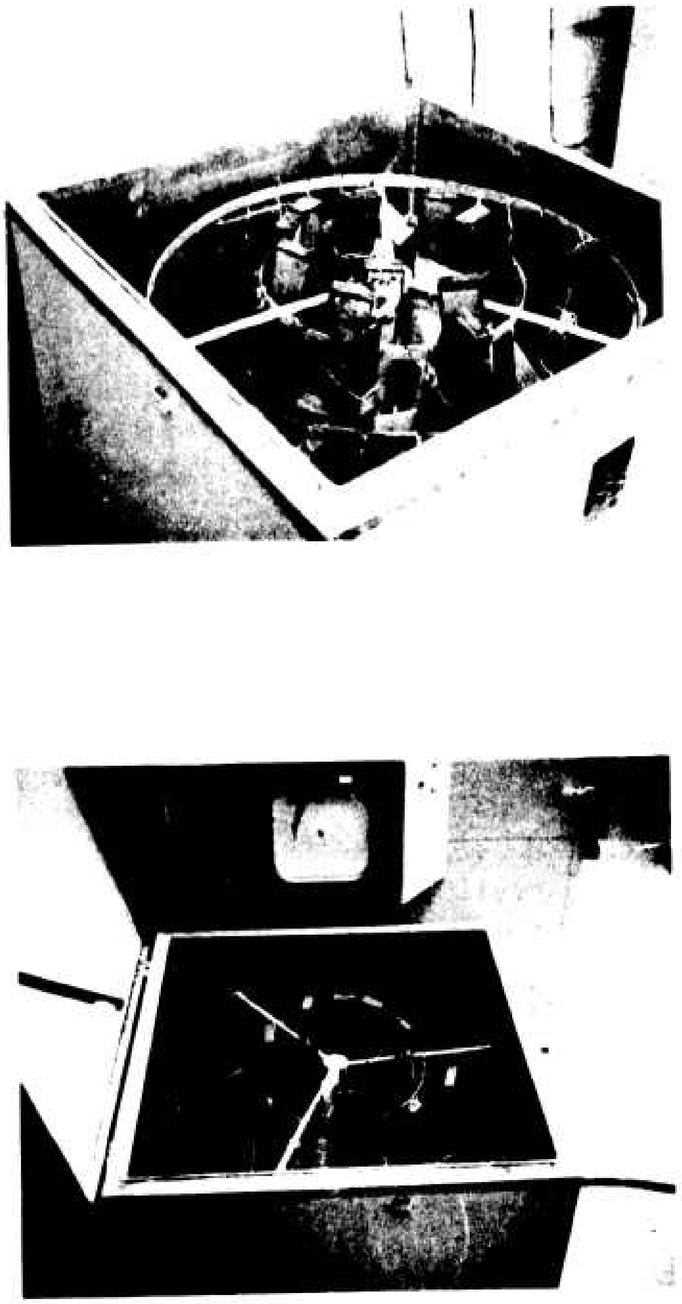


Figure 77. Conditioning Long Beam Sandwich Beams for Fatigue Testing in Condensing Humidity Chamber (100 Percent Humidity) at 120°F for 30 Days.

Figure 78. Atlas Weatherometer Used for Conditioning Artificially Weathered Specimens.

Figure 79. Specimens to be Placed in Condensing Humidity Chamber. Edges Were Sealed With 3 Coats of Neoprene Rubber for Prevention of Moisture Absorption in the Core and Inner Fiber Glass Facings.

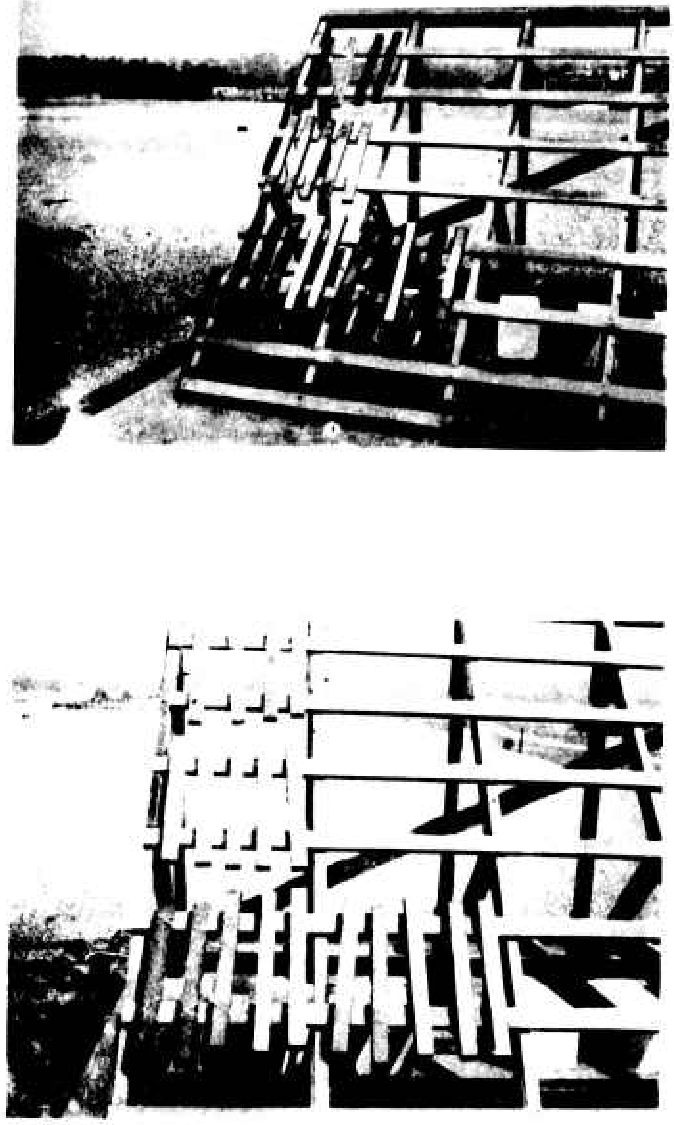


Figure 80. Sandwich Beams Undergoing Natural Weathering for a Period of 1 Year.

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13. ABSTRACT
The static and dynamic properties of alumino-silicate S-glass prepreg materials were investigated. Utilizing a series of process fabrication parameters, solid laminates, sandwich beams. Tubular specimens were fabricated by fluid pressure (autoclave) techniques.

The ultimate strengths and fatigue endurance limits of the specimens were determined over an ambient temperature range of minus 65°F to 160°F. The effects of actual weather, artificial weathering and condensing humidity on structural properties were also determined.

A means of reducing room temperature fatigue data on a statistical basis was developed to account for the processing and environmental parameters. Design properties for the materials in helicopter rotor applications are presented in the form of S-N curves.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Prepreg						
Scotchply						
S-glass						
Unidirectional Laminates						
Interlaminar						
Crossply						
Sandwich beams						
Torsion tubes						
S-N curves						
Mean-minus-three standard deviation						
Fatigue strength						

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